



**HI-TECH HOT ROD**  
THE LEAN & MEAN 2018 MUSTANG

**Alien asteroid**  
MEET OUR FIRST INTERSTELLAR VISITOR

# HOW IT WORKS

DO YOU ONLY USE  
**10%**  
OF YOUR BRAIN?


# 51 MYTHS BUSTED

THE FACTS YOU NEED TO FIGHT **BAD SCIENCE,**  
**FAKE NEWS & CONSPIRACY THEORIES**

**INSIDE**



**ROBOTS ON MARS**  
HUNT FOR LIFE WITH NASA'S NEXT-GEN ROVER



DOES IT TAKE  
7 YEARS TO  
DIGEST GUM?



DID HUMANS EVOLVE  
FROM CHIMPS?



WOULD YOU EXPLODE  
WITHOUT A SPACESUIT?



CAN YOUR PHONE BRING  
A PLANE DOWN?



**INFILTRATE  
FORT KNOX**  
The hi-tech security systems  
that guard America's gold



FUTURE  
ISSUE 108

**FREAKY  
FROGS**  
Meet the curious creatures  
with see-through skin



**PLUS** VENETIAN GONDOLAS | **TIGHTROPE PHYSICS** | TUBE MAPS | **ROMAN BATHS**



**TWO GREAT SHOWS TOURING THE COUNTRY!**

**'IT'S  
SO MUCH  
BETTER  
THAN THE  
BOOK!'**  
DAVID  
WALLIAMS

# David Walliams **GANGSTA GRANNY**



**'TOTALLY GRANTASTIC!'**

MAIL ON SUNDAY



# David Walliams **Awful Auntie**

**LIVE  
ON  
STAGE!**



**'ANOTHER HUGE  
DRAMATIC HIT!'**

WHAT'S ON LIVE



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# WELCOME

ISSUE 108  
The magazine that feeds minds!



One of the most active comment threads on our website is beneath a page about the curvature of the Earth. To our surprise, this innocuous article has

managed to spark an aggressive debate among online readers, because – inexplicably – some people believe the Earth is flat.

While this illogical belief is (hopefully) rare and very straightforward to debunk, there are plenty

of other myths and misconceptions in science and history that have become 'general knowledge'. Everybody knows that the Sun is yellow, Napoleon was short and a coin toss has a 50/50 chance of landing heads or tails. Right? Think again...

This month, we aim to separate fact from fallacy in our myth busting special, and we hope you learn something new. Enjoy the issue!

**Jackie** Jackie Snowden  
Editor

*"Photographs taken by satellites, probes and the ISS show our Earth as a beautiful globe"*

Conspiracy theories debunked, page 12

## Meet the team...



**Charlie G**  
Production Editor

From lightweight knights to discovering Marie Antoinette wasn't the first to extol the virtues of cake in a crisis, a host of historic 'facts' unravel on page 38.



**Baljeet**  
Research Editor

Did you know that Venetian gondolas are still made by hand, and due to a law passed in 1562 they have to be painted black? Find out more on page 63.



**Charlie E**  
Staff Writer

Did you know that the Titanic was never called 'unsinkable' until she was sitting at the bottom of the Atlantic? It seems unbelievable, but it's true. Find out more on page 28.



**Scott**  
Staff Writer

It's life guys, but not as we know it! On page 67 you'll learn about the rover that will be shooting through the Solar System in 2020 on a mission to look for life on Mars.



**Duncan**  
Senior Art Editor

In 1969 we actually landed on the Moon, for real! It's no hoax. Or is it? Find out the truth plus much more in our massive myth buster feature from page 12.



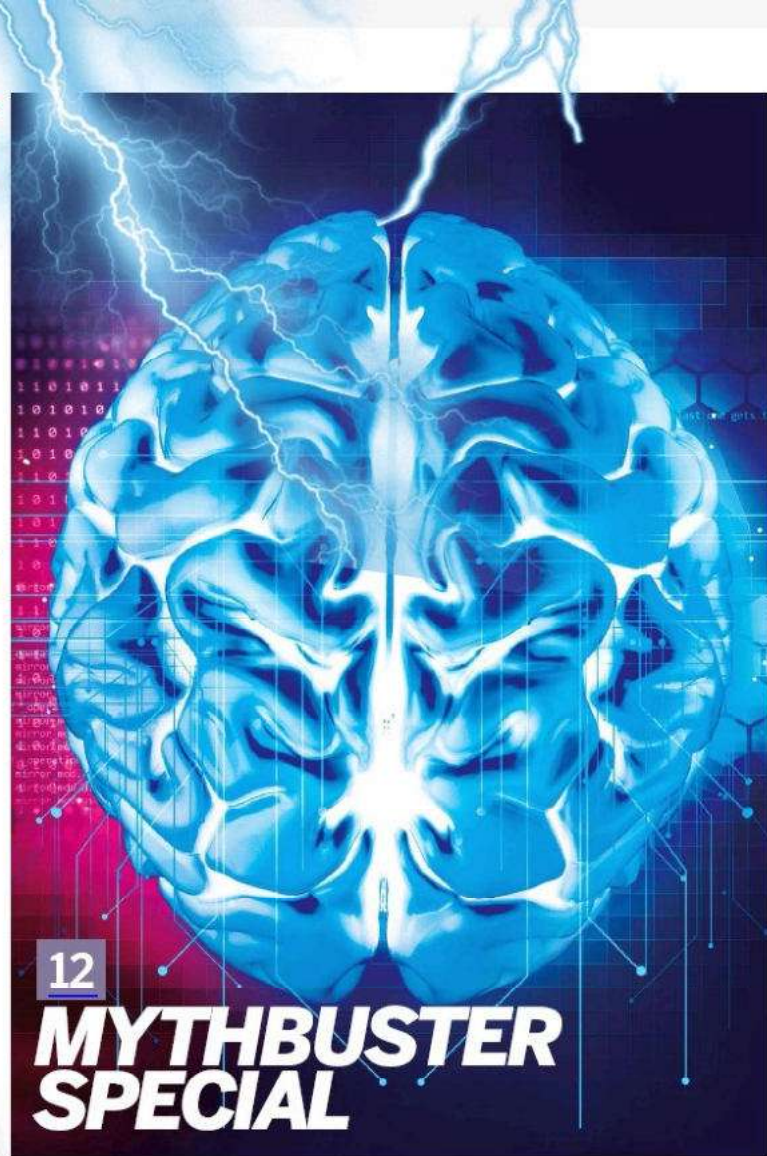
**Laurie**  
Studio Designer

From clouds that literally weigh a ton to not-so-forgetful goldfish, I was truly amazed by some of the myths that are completely busted over on page 34.

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We bust some of the most common misconceptions and unravel some of the strangest conspiracy theories

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- ▶ "You only use 10% of your brain"
- ▶ "Shuffle is completely random"
- ▶ "Lots of planes and ships go missing in the Bermuda Triangle"
- ▶ "You would explode in space without a spacesuit"
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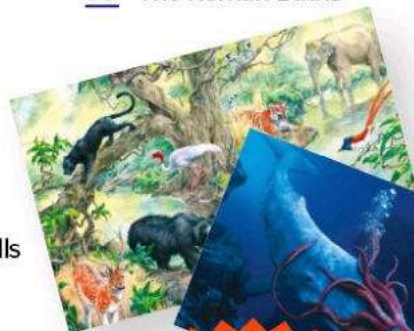
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## Meet the experts...



**Laura Mears**  
This month, Laura sets the record straight on some of the most widely accepted science myths. She also debunks some common conspiracies and explains the psychology of the believers.



**Jonny O'Callaghan**  
Jonny tackles the space section of our mythbusting special, explaining the reality behind the fantastical misconceptions surrounding our Solar System.



**James Horton**  
In this issue, James separates the hype from the headlines to explain what's really going on with our gadgets. Do video games make people more violent? And why do our devices slow down as they age?



**Tim Williamson**  
Our perceptions of the past are sullied with misquotes, mistranslations and downright lies. Tim delves into the history books to sort fact from fiction. He also reveals the fascinating story of the Roman Baths.



**Jodie Tyley**  
In this month's history section, Jodie uncovers the origins of the now-famous Tube map design. She also explores Portugal's mysterious megalithic monument and busts some historical myths.



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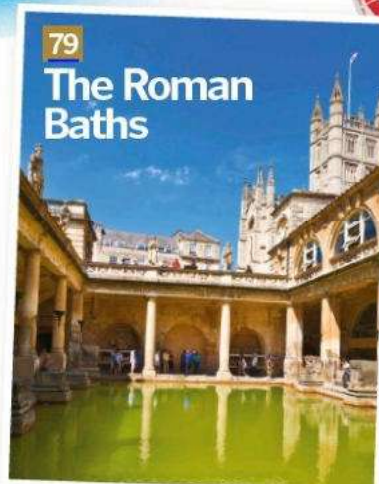


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## Ancient mummies are turning into black jelly

Researchers watch on powerless as decay blights important 7,000-year-old human remains

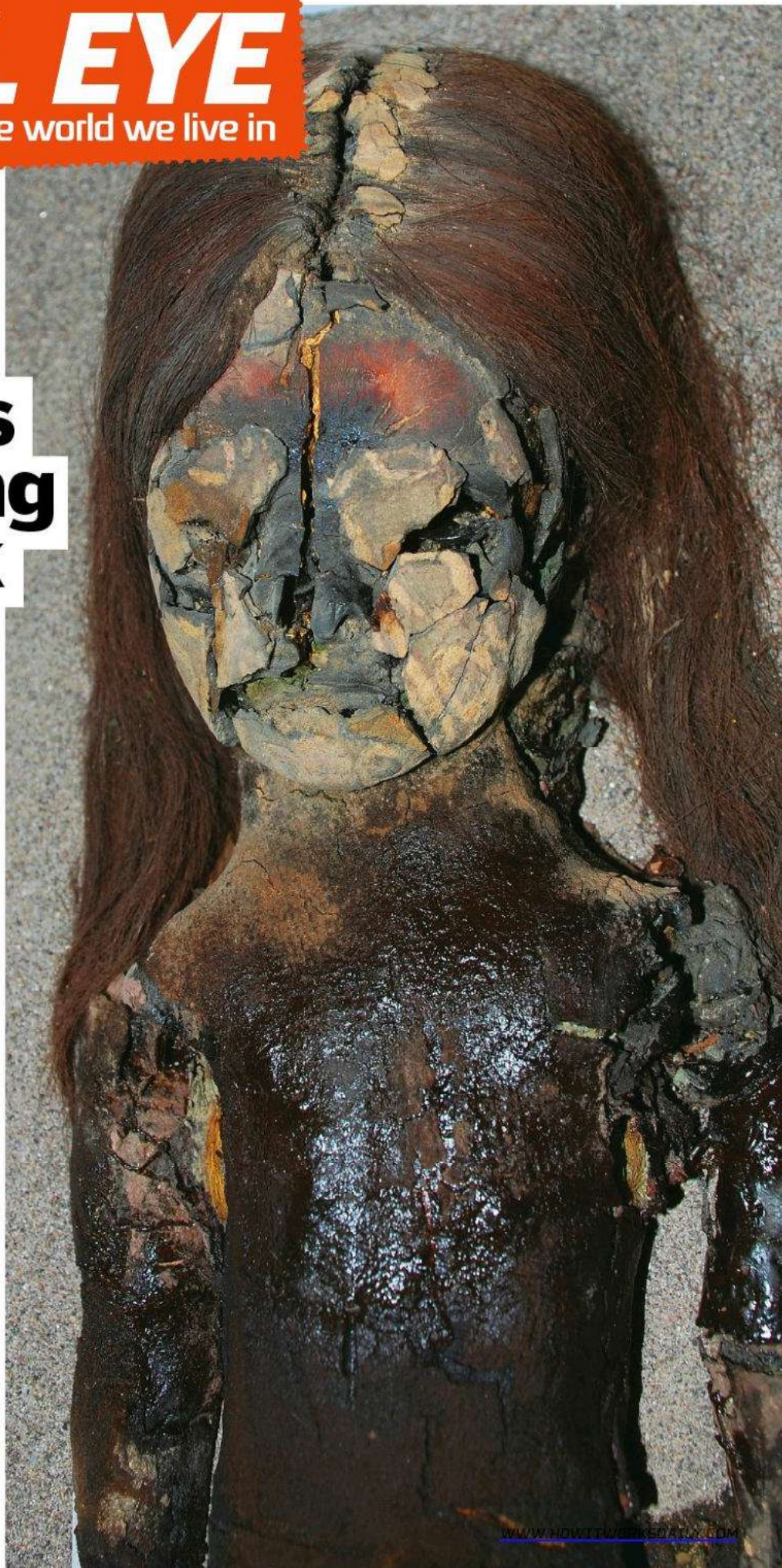


Scientists in northern Chile are frantically searching for solutions to preserve rare 7,000-year-old mummies that have suddenly started turning into black goo. More than 100 mummies have succumbed to what is thought to be a bacterial infection from modern-day contamination, causing the opportunistic microbes to begin feasting on the ancient remains. It is hypothesised that increased humidity and higher temperatures have aided the rapid bacterial proliferation, which is speeding up the degradation process.

The mummies were made by the Chinchorro people of prehistoric South America, who are thought to have first started preserving their babies and children who died from environmental arsenic poisoning. These hunter-gatherers started preserving their dead in this way approximately 2,000 years before the ancient Egyptians began following a similar process to preserve the bodies of their pharaohs.

The Chinchorro specimens are largely intact, and range from infants to older adults. Scientists working to preserve the mummies are applying to have the samples recognised by UNESCO as a World Heritage Site in the hopes a larger international community will be able to help.

**Right:** This Chinchorro mummy at the San Miguel de Azapa Museum in Arica, Chile, has begun to degrade





This mummified corpse, estimated at between 4,000 to 8,000 years old, gets a clean



**Left:** the mummies have been excavated from valleys in northern Chile, where the Chinchorro people lived around 7,000 years ago

**Above:** mummification was a common body preservation method, most famously used by the ancient Egyptians

## How Chinchorro mummies were made

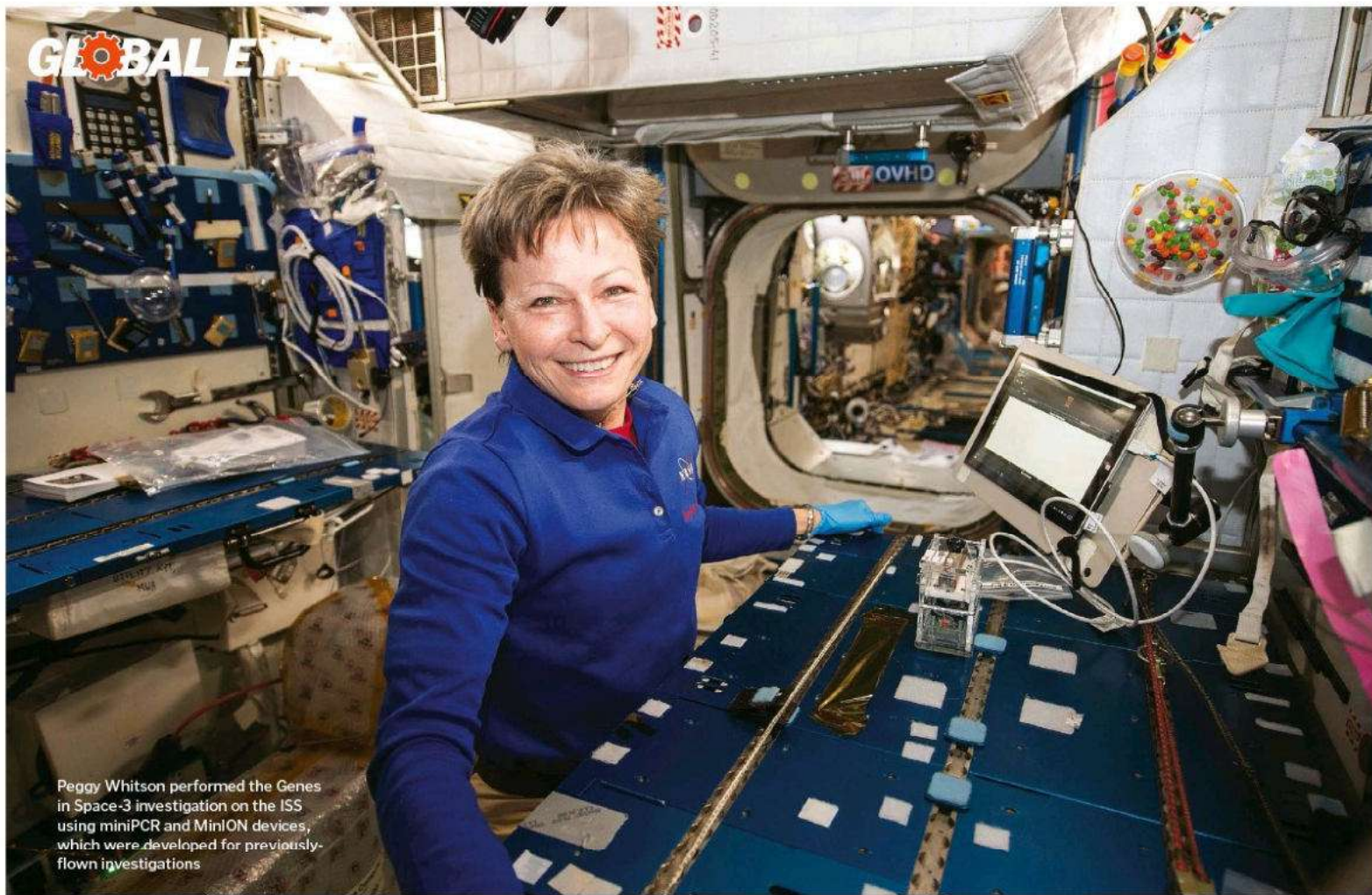
The Chinchorro primarily used two methods to preserve their dead: black mummification from 5,000–3,000 BCE and red mummification from 2,500–2,000 BCE. The black mummy technique involved separating the head, arms and legs of the deceased person and drying the body using heat before the flesh was stripped from the bone. The brain was then removed by cutting the skull in half at about eye level. The skull and body were then packed with material such as feathers and then tied back together.

A red mummy, on the other hand, had incisions made in the trunk and shoulders of the body to remove the internal organs and dry the cavity, and the head was completely removed from the body. The body was then stuffed with materials before being sewn up, with the head reattached after the brain had been removed. A human-hair wig would then be placed on the head, and everything apart from this single item would be painted with red ochre, a substance common in south Brazil.



Chinchorro mummies are among the oldest and best-preserved human-made remains ever discovered





Peggy Whitson performed the Genes in Space-3 investigation on the ISS using miniPCR and MinION devices, which were developed for previously flown investigations

# MICROBES SEQUENCED ABOARD THE ISS FOR THE FIRST TIME

The genes of bacteria carried to the International Space Station from Earth have been identified in space



Astronauts no longer have to rely on inter-orbital post when they wish to identify microbes aboard the ISS, because the Genes in Space-3 project has found a way to do it right there on site.

Although a concerted effort is made to sterilise everything on board prior to launch, humans inevitably bring bacteria into space with them. Previously, it has not been possible to find out exactly what microbes astronauts inadvertently carry there, as there was no way to perform experiments on the station. Until now.

So far, all of the microbes have been found to originate from Earth. This might not sound exciting, but this new ability to sequence genes in space means that it may be possible to diagnose astronauts who fall sick during their time on the ISS, or study the effects of micro-gravity on bacteria, or perhaps even identify organisms from extraterrestrial soil samples.

The successful completion of this sample-to-sequence process is revolutionary for the world of microbiology and space exploration. In 2017,

NASA astronaut Peggy Whitson was the first-ever person to conduct this experiment. Whitson collected various samples by touching petri dishes to surfaces throughout the spacecraft and then had to wait for bacteria to grow. After transferring the bacteria into a test tube, they

were collected and isolated. A technique called polymerase chain reaction (PCR) was then used to amplify (make many more copies) of the amount of DNA in the sample before undergoing sequencing and identification. These results were confirmed to be the same on the ground.

## The first Genes in Space project

Genes in Space-1 was the first project to use PCR in space to amplify DNA using a miniPCR thermal cycler. This 2016 groundbreaking experiment was quickly followed by another important study using the Biomolecule Sequencer, which used the MinION device to sequence DNA.

After results from the Biomolecule Sequencer investigation were published in scientific journals, the next appropriate step was to marry the two projects together to create an even more impressive experiment - a full microbial identification process while in space. This is the Genes in Space-3 project.



Astronaut Kate Rubins with the MinION device during the first run of the Biomolecular Sequencer investigation



## **+ NEWS BY NUMBERS**

**68.1  
billion**  
the number of songs  
streamed in the UK in 2017

**7.3mn  
tons**  
of waste plastics were  
imported to China in 2016,  
which recently banned  
such imports

**0**  
There were no fatalities in  
commercial passenger jet  
crashes in 2017

**50  
YEARS**  
30 December 1967  
marked the publication  
of the discovery of  
synthetic DNA

This is the first indisputable  
evidence that supermassive  
black holes are contributing  
to the star formation process

**GLOBAL EYE**

## **Supermassive black holes influence star formation**

One mystery surrounding the effects of black holes has been solved



A young galaxy bursts with bright new stars, but as the galaxy ages star formation slows dramatically. Until recently the cause has been a complete mystery, but a new study published in *Nature* on 1 January 2018 found that the mass of the supermassive black holes exert control over star

formation. Researchers from the University of California Santa Cruz showed that higher-mass central black holes quench star formation earlier and more efficiently than their smaller counterparts (and visa versa). It is a theory that has been hypothesised for decades, but until now had remained unproven.



The new species is  
closely related to  
the giant Pacific  
octopus (pictured)

## **New giant octopus species discovered**

This octopus is so good at camouflage that it had  
scientists convinced it was a different species



Scientists have discovered the  
frilled giant Pacific octopus after  
mistaking it for the giant Pacific  
octopus for years.

Researchers Nathan Hollenbeck and  
David Scheel from Alaska Pacific University  
have found photographic evidence to  
confirm genetic studies of the two differing  
species. The study was performed in

Alaska and involved searching for the  
octopus in shrimp pods.

The new evidence shows that the frilled  
giant Pacific octopus can be distinguished  
from other species by the frill of fleshy  
bumps on its skin that run the length of its  
body. Additionally, the newly identified  
species has two white spots on its head,  
while the original octopus has only one.

## **A new self- healing glass has been created**

Are shattered phone screens soon  
going to be a relic of the past?



A new self-healing polymer has been created by  
researchers at the University of Tokyo. Originally  
on a quest to find a new adhesive, the new  
substance can heal itself from cracks when it's pressed  
together for 30 seconds at room temperature. The glass  
relies on polyether-thioureas, and exploits the ability of  
hydrogen to form bonds in such a way that allows the  
chains to freely move and recombine when compressed.



A two centimetre squared section of the new material  
can hold up to 300 grams of weight

© A Himma / YouTube, NASA, WIKI / Bachsch44



# GLOBAL EYE

# 10 COOL THINGS WE LEARNED THIS MONTH

## 1 Bio-ink could print organs

3D printing technology has come a long way in recent years, especially in the medical sector. Bioprinting still has many hurdles to overcome, such as getting the ink to stick together. However, Japanese researchers may finally have found a way to achieve this. The new enzyme-driven approach enables biological cells to bind together, which could allow complex structures to be printed, such as organs.

## 3 Indonesia is rich with cave paintings

Previously unexplored by archaeologists, the small island of Kisar has revealed a wealth of cave paintings. 28 rock art sites have been discovered by the team, dating back at least 2,500 years. They depict various scenes, including boats, dogs, horses and humans possibly holding shields. Similarities to paintings found on the neighbouring island of Timor suggest a relationship between the two civilisations.

## 2 Exercise slows progression of Parkinson's

Researchers at the University of Colorado have linked the benefits of exercise to decreasing symptoms of Parkinson's disease. The neurological condition is caused by the death of certain neurons, and a hallmark of the disease is the accumulation of the protein alpha-synuclein in the brain. In a study of mice, those that ran on a wheel expressed a gene that codes for the DJ-1 protective protein, which prevents the 'clumping' of alpha-synuclein and therefore slows down the physical effects of the condition.

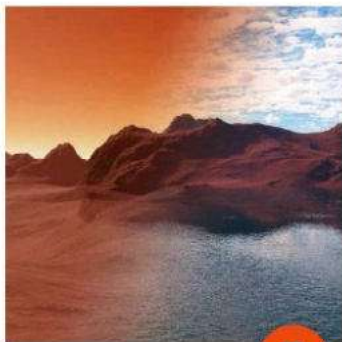
O10 | How It Works

## 4 Polyps protect coral reefs

Coral polyps, or hydrozoans, are tiny marine creatures related to jellyfish and anemones that live on the surface of hard corals. However, following a study of almost 2,500 coral colonies in Maldivian and Saudi Arabian reefs, researchers have found that polyps do more than just take up space. When more than 50 polyps per square centimetre reside on a reef, they act as a line of defence against predation from fish and gastropods, such as snails. Polyps release a venomous organelle called a nematocyst, similar in function to a jellyfish sting. As the polyps are smaller than one millimetre they don't pack much of a punch alone, but in masses they can help to fend off intruders.

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## Mars isn't that dry

5

Where did the water go from Mars? Scientists at Oxford University have proposed that the majority of its water never left the planet and is held in basalt rocks, which can hold approximately 25 per cent more water than those on Earth.



## Emissions could become fuel

6

Researchers at MIT have developed a system in which carbon dioxide can be processed at any quantity to produce fuels such as liquid hydrocarbons or methanol. The system involves passing carbon dioxide through a membrane that only allows oxygen atoms to pass through, leaving behind carbon monoxide. The process is driven by solar-generated heat and can be combined with hydrogen and/or water to produce other fuels.



## Robots can think like insects

7

The RoboBee is an 80-milligram robot inspired by the anatomy of insects, and now engineers have developed an algorithm to allow it to face the elements. To avoid environmental factors such as wind, engineers at Cornell University are developing a neuromorphic chip to mimic the neural functions of insects. These clever chips will process information by spikes of electrical currents, in the same way neurons fire in the brain.



## There is a winking star

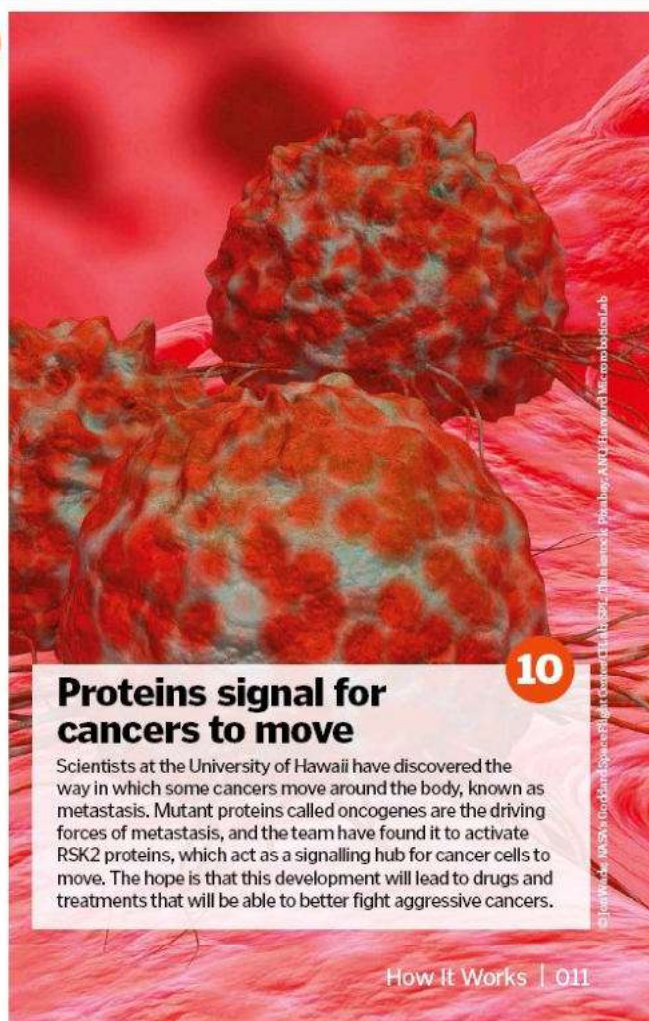
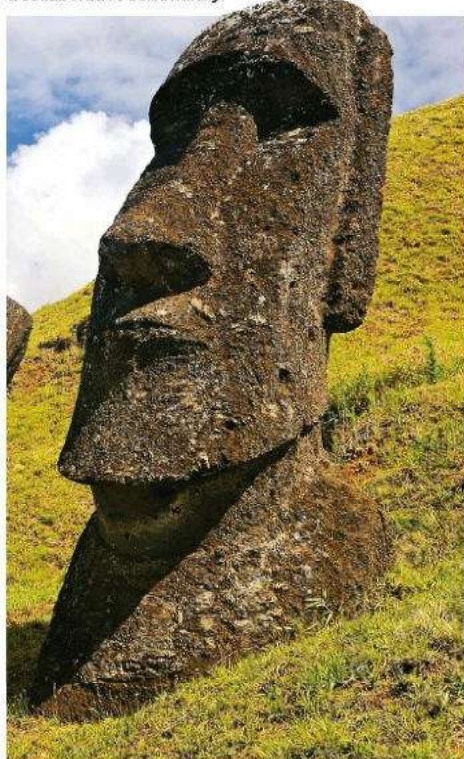
8

Located about 550 lightyears away, the star RZ Piscium experiences erratic dimming episodes, as if to give NASA a wink. The episodes have been attributed to clouds of gas and dust from the planetary debris orbiting the star, blocking the star's light as it passes by.

## Easter Island wasn't home to just warriors

9

It was previously believed that Easter Island was home to a culture of warriors. However, a study by Binghamton University in the US has revealed it was a much more cooperative community. By studying the 'hats' of the iconic human statues (known as moai) with 3D computer models of the volcanic rock, researchers discovered previously unseen carved drawings depicting a collaborative community.



## Proteins signal for cancers to move

10

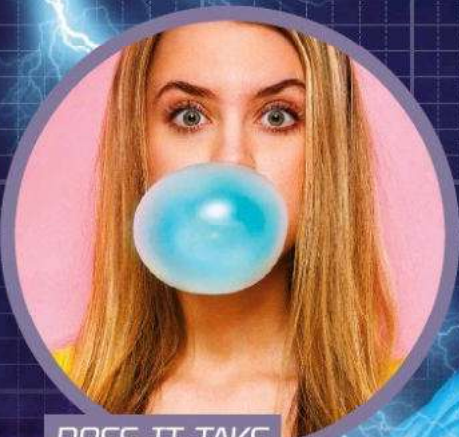
Scientists at the University of Hawaii have discovered the way in which some cancers move around the body, known as metastasis. Mutant proteins called oncogenes are the driving forces of metastasis, and the team have found it to activate RSK2 proteins, which act as a signalling hub for cancer cells to move. The hope is that this development will lead to drugs and treatments that will be able to better fight aggressive cancers.





CONSPIRACY MYTHS

**BUSTED**



DOES IT TAKE  
7 YEARS TO  
DIGEST GUM?

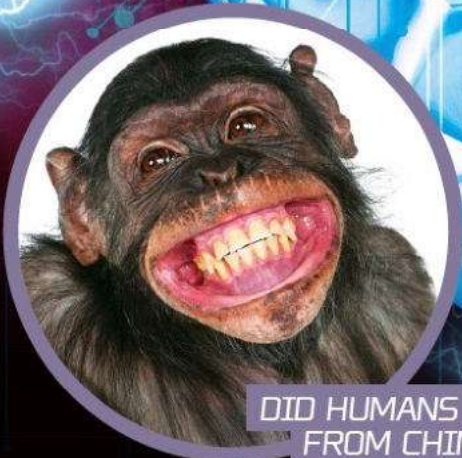


CAN YOUR  
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DO WE ONLY  
USE **10%** OF OUR

# BRAIN POWER?

**REVEALED** THE TRUTH BEHIND OVER **50** MYTHS,  
MISCONCEPTIONS & CONSPIRACIES



DID HUMANS EVOLVE  
FROM CHIMPS?



WOULD YOU EXPLODE  
WITHOUT A SPACESUIT?



# Discover the truth behind the myths and the psychology of the believers

## "THE MOON LANDINGS WERE FAKED"

Nearly 50 years on from what is possibly humanity's greatest achievement, conspiracy theorists have pored over the footage of the Moon landings from 1969 and they think it's a set up. They believe NASA built a studio on Earth, attached actors to wires and simulated low gravity with slow-motion filming, all to trump their Soviet rivals in the space race. NASA says they put men on the Moon. So, what really happened?

The lighting has been a topic of much debate, with conspiracy theorists claiming that one of the most iconic images of Buzz Aldrin could only be taken with an artificial light source. So computer graphics experts simulated real-time

lighting properties at the Apollo 11 landing site. It turns out that Neil Armstrong's spacesuit reflected the Sun's light and was responsible for illuminating Aldrin in the iconic 1969 photo.

Perhaps the best proof of the Moon landings is the trail of evidence left by the astronauts. The Apollo 11 mission brought Moon rocks back to 135 countries for their scientists to examine, and they have confirmed their lunar origin. The astronauts also planted reflective panels on the surface of the Moon; when other countries shot lasers at them, they pinged back a signal. If the Moon landings were a hoax, researchers from across the globe would have had to have been in on the conspiracy too.

## Moon conspiracies debunked

### "YOU CAN'T SEE THE STARS"

The Moon has no atmosphere, so shouldn't the stars be visible? Like spacesuits, Moon rock reflects sunlight. It is too bright on the surface to see the dim light from distant stars.



### "THE ROCKS ARE PROPS"

This rock appears to have the letter 'C' on it, but it's only present in enlarged images, not in the original NASA images, so it's more likely to be a stray hair on the film.



### "SHADOWS ARE DIFFERENT LENGTHS"

Some think the inconsistent shadows reveal many light sources, but they can be explained by the rocky, hilly terrain. The landscape of the Moon casts shadows at different lengths.



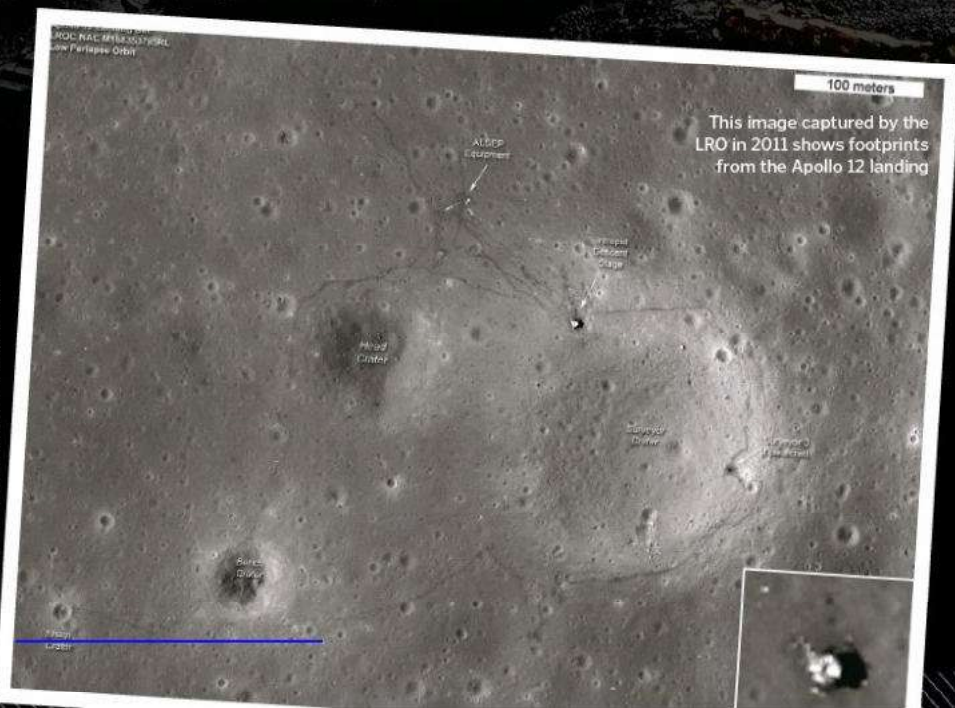
### "THE FLAG IS FLAPPING"

There shouldn't be any wind, but the flag waves as it's planted. It's just the astronauts twisting it to get it into the ground. It stays still later on.



### "IT WAS FILMED IN SLOW MOTION"

Were the astronauts held up with wires and filmed in slow motion? Look at the dust — it drops straight down to the ground. On Earth it would form clouds because of the air in the atmosphere.







Contrails only form in certain atmospheric conditions

## "PLANES ARE SPRAYING TOXINS OVER US"

If you look up outside you might notice the blue sky strewn with artificial reflective clouds. These telltale streaks of white are called contrails, and they are produced by aircraft exhaust emissions. Contrails form when the hydrocarbon content of jet fuel produces water as a by-product of combustion. The water mixes with cold, wet air and condenses, and it can freeze to form ice crystals. However, some believe that there is a more malevolent undercurrent to the goings-on in the upper troposphere and lower stratosphere.

Most advocates of the so-called 'chemtrails' conspiracy recall seeing fewer and less lingering contrails when they were younger. However, this can be explained by the dramatic increase in air traffic we've seen over the last few decades, as well as cooler exhaust emissions thanks to increased fuel efficiency.

Unsurprisingly, the evidence for chemtrails isn't compelling and remains built on pseudo-scientific principles. Conspiracy theorists' claims range from the idea that government agencies are attempting to turn clouds into spying devices to control our minds, to the notion that they are spraying chemicals to deliberately make us sick.

There is one peer-reviewed paper on the topic, and it doesn't support the outlandish secret spraying scandal. The researchers asked 77 atmospheric scientists to review the data for evidence of chemtrails. Only one scientist said there was a possibility some of it could be evidence, but they also articulated that it wouldn't be the only explanation.

The chemtrail conspiracy theory first emerged shortly after a paper entitled *Weather as a Force Multiplier* was published by the US Air Force in 1996. The article outlined speculations by military researchers about whether the ability to control the weather could be useful in combat. Though the US Air Force have maintained that this was purely hypothetical, it is understandably a chilling thought. Even so, there's nothing up in the air with this one: the scientific data confirms that contrails are completely harmless.

# "VACCINES CAUSE AUTISM"

This dangerous myth all started when a fraudulent study led by Dr Andrew Wakefield was published in the highly respected medical journal *The Lancet* in 1998. He studied children diagnosed with autism after receiving the combined vaccination for measles, mumps and rubella (MMR). He claimed that the vaccine caused autism and bowel disorders. Parents quickly stopped vaccinating their children. Another theory falsely implicates the use of thiomersal, a mercury-based vaccine preservative, with autism.

In the years that followed, more rigorous studies found no link between the MMR vaccine and autism: Wakefield was wrong. Ecological studies looked at the numbers of vaccinated children versus the number of children with autism. In Canada, autism rates increased while MMR vaccination rates went down. Sweden and Denmark removed thiomersal from vaccinations

in 1992, but autism rates continued to rise. Retrospective cohort studies looked back through medical records to find links. One Danish study analysed over 537,000 children but found no link between their vaccination date and autism diagnosis. Prospective cohort studies followed children after vaccination to see if they went on to develop autism. In Finland doctors found 31 children with symptoms described by Wakefield but none became autistic. Then there was a meta-analysis conducted by Taylor et al that gathered results from more than 1.25 million children. They found no link either.

Measles, mumps and rubella are dangerous infections that can cause deafness, meningitis, brain swelling and death. In 2010, *The Lancet* retracted Wakefield's paper, with the UK's General Medical Council striking Wakefield off the medical register for serious professional misconduct in the same year.



The full course of MMR vaccine requires two doses

## BAD SCIENCE Why was Wakefield's research eventually discredited?



### Statistics

There were only 12 children in Wakefield's study — not enough to draw a firm conclusion.



### No control data

The children in Wakefield's study weren't compared to children who hadn't had the MMR vaccine.



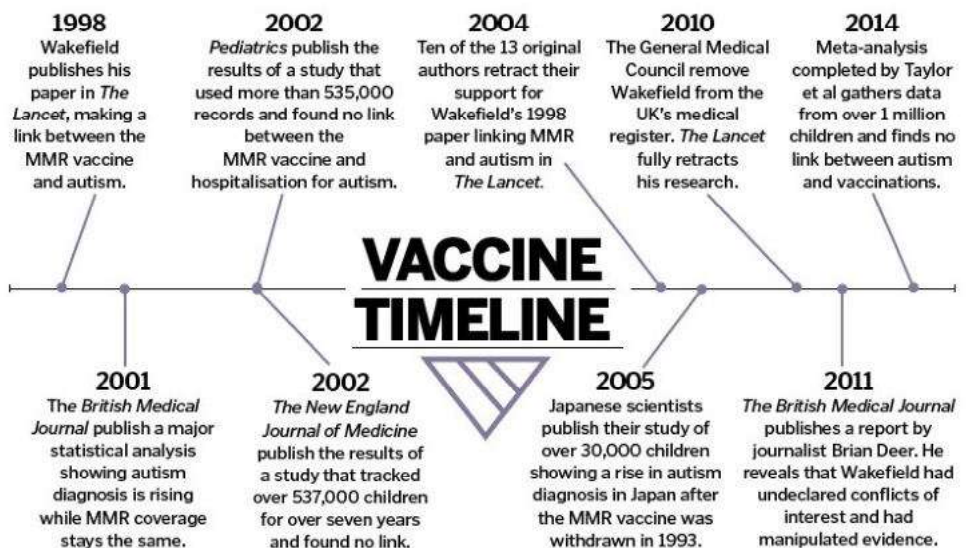
### Memory

The paper relied on parental anecdotes, which are not a reliable form of evidence.



### Vague conclusions

The conclusions made in the paper were speculation and were not based on solid evidence.







Crop circles come in all shapes and sizes, from simple circles to complex designs

## “CROP CIRCLES ARE MADE BY ALIENS”

As giant discs carved among crops, the origins of these elaborate designs have been debated for decades. Some claim that aliens are using fields as notepads in an attempt to communicate with us. Others believe that they are made by human time travellers sent back to warn the present-day population. Others think it could be a strange natural phenomena.

Large proportions of circles occur in southern England, and in recent years patterns have become larger and more detailed. Those who favour a more extraterrestrial explanation believe they are created by spaceships or invisible energy beams from space. Reports of crop stem nodules morphing and elongating have been theorised to be the result of exposure to an

unexplained source of microwave radiation. But, while there is physical evidence of crop circles, their presence has a scientific explanation.

The prevailing theory, which is supported by evidence, is that humans carve the circles. Commonly named ‘the circle makers’, groups of artists have been observed during their sculpting and even interviewed about their work. It appears the trick is to leave no trace of entering and exiting the fields, which they do by working under the cover of night. Artists have been known to use a length of rope and wooden boards to flatten the crops and form creative shapes. Though aliens aren’t responsible for the circles, some of these impressive designs are out of this world.

## Why do people believe conspiracies?

Part of it is down to proportionality bias. It is a tendency of the human brain to convince us that big events must have a big cause. Rather than accept the simple explanation, it’s somehow easier to believe an elaborate conspiracy.

Another factor is projection bias. We think that other people think like us, and if we’re suspicious, or behave suspiciously, we believe that others will be hiding the truth too.

Then there’s confirmation bias. We’re much more likely to accept evidence that agrees with our existing beliefs than evidence that contradicts us. Once someone gets invested in a conspiracy, they’ll become more and more convinced that it’s true.



We are more likely to accept evidence if it agrees with beliefs we already have



## “CLIMATE CHANGE IS A HOAX”

It goes without saying that climate change is a very hot topic in today’s political climate, and while most of us accept that it’s a very real challenge, there are some who still refuse to believe it. From those that think the whole idea was invented by some countries to reduce the economical value of others, to those that believe it’s simply fake news, the conspiracies about climate change abound.

Climate change itself isn’t something new for Earth. Our planet has experienced many fluctuations of global warming and cooling that have been recorded through ice core studies. However, the rapid changes we are witnessing today are believed to be driven by human behaviour. Well, believed by some. President Trump regularly airs his scepticism via Twitter: “Record low temperatures and massive amounts of snow. Where the hell is GLOBAL WARMING?”

Some assume there should be a direct relationship between global warming and their local weather, so by that logic the presence of snow or abnormally cold weather in their hometown must mean that global warming is a lie. But the clue is in the name: the temperature occurs on a *global* scale rather than just on a snow-dusted doorstep. Since the late 19th century the global temperature has risen by 1.1 degrees Celsius, with the rise escalating in the last 35 years to make 2016 the warmest year on record. However, global temperatures are just one of many figures used to illustrate climate change.

Sea levels have risen by about 20 centimetres since the beginning of the 20th century, and since the Industrial Revolution ocean acidity has increased by 30 per cent, causing certain species to relocate as a result. Global warming and climate change might be an inconvenient truth, but they are an unequivocal truth nonetheless.



# "THE EARTH IS FLAT"

By around 500 BCE most ancient Greeks believed our planet was round. For a long time before this it was believed to be flat. It was only when we started to map the trajectory of the Sun and the stars and applied mathematics to speculation that we rejected the disc model and accepted the spherical model. You can see the evidence of this curve yourself. Just sit on a clear day and watch a sailing boat as it cruises over the horizon, and you will see it slowly disappear as it dips beneath the horizon and eventually out of sight. This was just one argument made by Aristotle (circa 384–322 BCE), who was possibly the first person to propose a spherical Earth based on physical evidence in around 350 BCE.

So what evidence do modern flat Earth societies have to continue to believe claims that are flat out unsubstantiated? These conspiracy theorists reject the irrefutable evidence of gravity and instead favour the position that we are on a disc that is being pushed upwards through space by a mysterious force called dark energy. They believe that our planet is a

disc-shaped world with the Arctic Circle in the middle, with a rotating dome of stars over our heads. Among other absurdities are theories that the Sun is only several hundred kilometres away from us, the Moon is transparent and a giant magnet under the ocean controls the tide.

Perhaps the most outlandish aspect of the flat Earth conspiracy theory is the belief that our planet is surrounded by a huge, 45-metre-high ice wall on the coast of Antarctica that holds our ocean in and prevents us from falling off the planet. Flat Earth conspiracy theorists not only reject the shape of the Earth but also deny the irrefutable evidence of almost all of the scientific evidence underpinning our understanding of physics, mathematics and our origins.



The model of a flat Earth is incorrect and has no scientific support

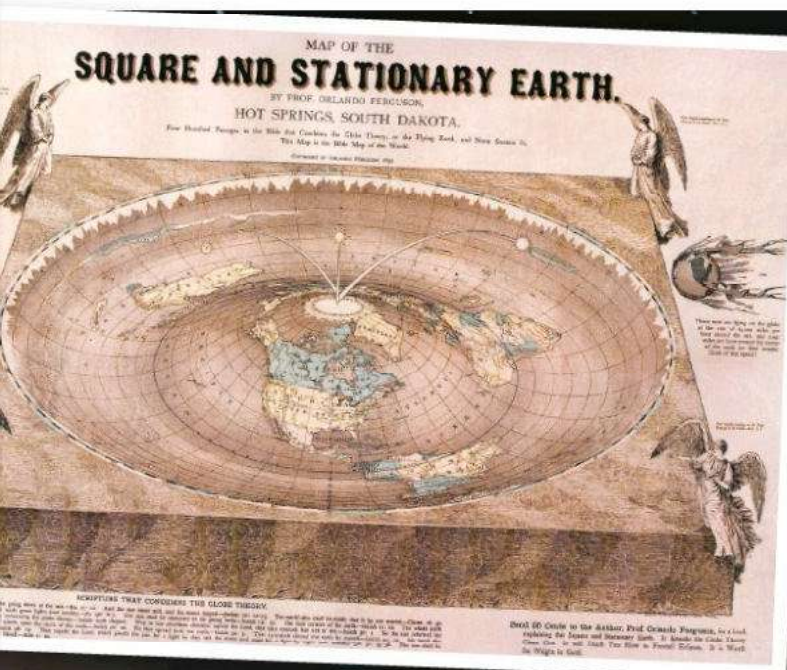
## Level horizon

According to some believers, the Earth must be flat as no matter how high you go, you never have to look down at the horizon.

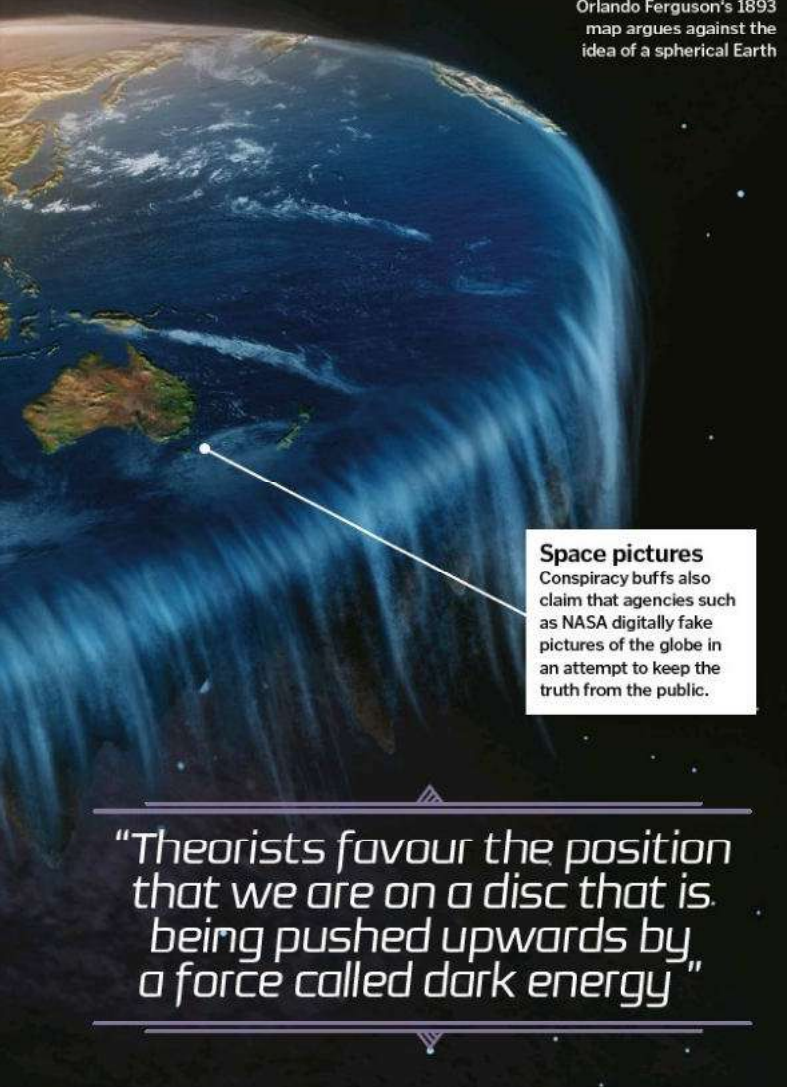
## Disc-shaped Earth

Flat Earthers claim that an ice wall prevents us from falling off our disc-shaped world into oblivion.





Orlando Ferguson's 1893 map argues against the idea of a spherical Earth



**Space pictures**  
Conspiracy buffs also claim that agencies such as NASA digitally fake pictures of the globe in an attempt to keep the truth from the public.

"Theorists favour the position that we are on a disc that is being pushed upwards by a force called dark energy"

## Five reasons why we know the Earth is round

### 1 PHOTOGRAPHY FROM SPACE

Countless photographs taken by satellites, probes and from the ISS show our Earth as a beautiful globe, which is unarguably the greatest piece of evidence that the world is not flat.



### 2 LUNAR ECLIPSE SHADOWS

During a lunar eclipse, the Earth is placed between the Moon and Sun. The shadow cast by our Earth is visibly round as a result of its spherical shape.



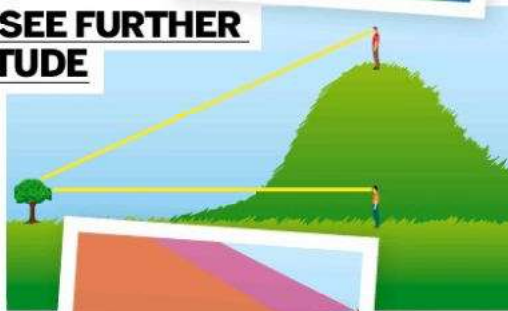
### 3 DIFFERENT VISIBLE CONSTELLATIONS

From a flat Earth all the stars would look the same no matter where in the world you were standing, but this isn't the case — different constellations can be seen in different parts of the globe.



### 4 WE CAN SEE FURTHER WITH ALTITUDE

The higher up you are the further you will see. This is a result of the Earth's curvature. On a flat Earth, elevation would not make a difference and curvature would thereby not occur.



### 5 TIME ZONES

If Earth was flat the Sun's light would be equally distributed everywhere; similar to placing a plate beneath a desk lamp. This would mean we wouldn't have any time zones, or day and night.





## We uncover some of the biggest falsehoods in technology



### “VIDEO GAMES MAKE PEOPLE MORE VIOLENT”

The idea that absorbing violent content through media encourages our own violent thoughts and actions isn't new. In fact, it's been around since violent scenes first appeared on the silver screen in the 1970s, with parents and conservative groups fearful of the negative impact viewing such things could have. The swift transformation of video games in the decades that followed, from family friendly titles such as *Super Mario* to the R rated *Grand Theft Auto* series, did nothing to allay their concerns.

Suddenly young adults, rather than just watch a person harm another in gruesome ways on the screen, could take control of an avatar and commit such virtual crimes themselves. In *Grand Theft Auto* — a famous example of such a game — players could even shoot or simply run down innocent bystanders. While these games were designed purely for entertainment, gamers found their appetites for on-screen violence ever increasing so scientists decided to step in and investigate their potential impact.

Several scientific findings have been published on the topic, and at first glance it seems like bad news for gamers. In a laboratory setting, numerous studies asserted the same conclusion: exposure to violence could invoke such behaviour in the viewer. However, a more recent comprehensive survey released in 2014 used crime statistics to debunk this view. The researchers compared rates of youth violence against consumption of violent video games and discovered the two were inversely related. The study had shown that youths were becoming less inclined to commit criminal violence with the rise of violent video games.



### “IT'S BEST TO LET BATTERIES RUN OUT BEFORE RECHARGING”

This battery myth, which supposedly helps to extend a device's lifespan, is a notorious example of an incorrect piece of information that seems to endure even when it becomes outdated. And, if we're able to admit it, most of us have probably shared this 'helpful' tip with others, unaware that our advice will actually harm their product's battery life rather than help it.

Most modern batteries, including all those used in our precious Apple iPhones and MacBooks, make use of lithium-ion batteries. Compare these to traditional battery technologies and you'll find that they are claimed to charge faster, last longer and, most importantly for addressing this myth, charge best in short, 'topping-up' bursts. Apple measures their battery lifespans in cycles, with one cycle being equal to 100 per cent discharge, but that doesn't mean that you should completely drain your battery before plugging in your device. Instead, it's best to split a charge cycle across multiple charges.

In fact, most tech advisors suggest never letting your phone battery get too low, nor too high. Not that a full-charge will be

overly damaging, but consistently leaving your device plugged in until it has stored every last drop of energy can reduce its lifespan in the long term. Instead, take advantage of your device's inbuilt charging design, which will likely be a 'quick-charge' to 80 per cent and 'trickle-charge' from 80 to 100 per cent. This design ensures that you can get power back quickly but stops your device from overcharging. So discard this common myth and stop waiting for your bar to empty before filling it up. Instead, keep your bar in the green, and charge from 40 per cent to 80 per cent for the most efficient battery life.



Contrary to popular belief, letting a modern battery's charge fall too low is damaging for its longevity



# "PLANNED OBSOLESCENCE MAKES YOUR PHONE SLOW DOWN"

Conspiracy theories can be fun to discuss, but they become so much more fascinating when they contain a grain of truth. Such is the case with 'planned obsolescence', a manufacturer's tactic that had been in play for decades before the term had even been invented.

In essence, planned obsolescence is a deliberate ploy by the manufacturer to limit their product's lifespan so the consumer is forced to repeatedly pay to replace it. And to the chagrin of today's manufacturers, conspiracy theorists often point to the infamous 'Phoebus cartel' of light bulb makers, who in the 1920s planned to do exactly that. But as technology has developed, attention has shifted away from light bulbs and onto smartphones, with recent theories suggesting that tech giants, such as Apple, restrict the performance of older devices in order to encourage consumers to purchase newer, more expensive models.

As this idea has inspired such widespread belief, software

company Futuremark decided to put iPhones, old and new, to the test. They assessed each model's performance every month for 18 months and found that their performance was maintained. The slowed-down performance owners had been reporting was more likely due to installing software updates released with the new models, which are designed to work optimally with the newest units.

However, in December 2017 Apple announced that their iOS software does in fact slow the performance of older iPhone models in order to preserve battery life. Old lithium-ion batteries don't hold their charge as well as new ones, so the programmed slow down is a compromise to stop the battery draining too quickly and to prevent random shut downs, which would otherwise be frustrating for users.

So is the slowing performance a scheme by manufacturers to boost profits? Not exactly.

Does their approach to software updates render old models obsolete? Eventually.

Although Macs can get viruses, they're not as common as in PCs

## "MACS CANNOT GET VIRUSES"

Lots of us long for a Mac of our own, with their sleek design, sophisticated hardware and intuitive software catapulting them to the top of many wish lists. Add to that the common notion that they're immune to viruses, and they almost sound like the perfect machine. Only, as more users are discovering, Macs are susceptible to viruses, spyware and other types of malware just like PCs.

However, this myth hasn't arisen from nowhere. Macs do encounter much less malicious software (often abbreviated to malware) than Microsoft PCs, which has led to their inflated reputation. A primary reason for this is simply that there are more people using PCs therefore making them the obvious target for opportunistic hackers. Today, with a growing number of Mac users around, hackers have more incentive to design viruses for Macs. However, by their very design, Macs are much better equipped to deal with possible threats, with their inbuilt security measures capable of restricting unknown applications from installing on the system. But, there is no computer that is completely secure.

Light bulb manufacturers have been revealed as exploiters of 'planned obsolescence' in the past



"Macs are susceptible to viruses just like PCs"







Camera advertisements often revolve around megapixels, but they are a measure of quantity not quality



## “MORE MEGAPIXELS MEANS BETTER PHOTOGRAPHS”

Like many tech-related myths, presenting megapixels as the sole determinant of image quality is a result of misleading marketing campaigns. And unfortunately for consumers, all the big phone- and camera-creating manufacturers have hopped onboard with this advertising strategy. But more doesn't necessarily mean better, and in some cases, more megapixels can even make your photographs worse!

Digital cameras — unlike their predecessors that captured images using light-sensitive film — build images through pixels, which each process a small fraction of light caught by the camera's sensors. With more pixels comes more units to capture incoming light, increasing the camera's resolution and providing images with more detail. This can be helpful when making large prints or zooming in on images, but otherwise you'll notice little difference between a seven- and ten-megapixel camera, for example.

It's also important to note that there are many more factors at play than just megapixels, with the camera lens, sensor, flash and software all being important elements. Plus, with more megapixels comes the requirement for more light to accurately capture the image, so a higher megapixel camera can produce lower-quality images than one with less megapixels when the other components are not up to scratch.

Shuffle play prevents tracks from repeating, making it distinct from a random play feature



## “SHUFFLE ON MUSIC PLAYERS IS COMPLETELY RANDOM”

Shuffle playlists are great when we're in an indecisive mood. Not sure what music to listen to? No problem. Just click 'shuffle' and the device will randomly choose songs from a playlist or library for you to listen to. Or will it? At least in the case of the music streaming service Spotify, the answer is no, it's not quite as random as you might expect.

Instead, they've designed an algorithm to make your shuffle playlist *seem* more random than a truly random playlist would be. And as bizarre as that sounds, it makes sense when we consider that humans are very good at making patterns — even when there aren't any. The algorithm attempts to circumvent a human invention known as 'gambler's fallacy', which explains our tendency to think that if a coin has landed on heads five times in a row, then it's likely to land on tails on the next toss. But really, every time we flip a coin, the chances of it landing on heads or tails is equal (well, more or less... see page 22).

When we hear an artist on shuffle appear twice in quick succession, we

instinctively wonder how the playlist can be random if the same artist has cropped up twice so soon. So Spotify have introduced the algorithm to separate an artist's songs in order to cater to what we perceive to be random.

Music streaming services such as Spotify use algorithms to make their playlists seem more random





# "MAGNETS CAN ERASE YOUR DATA"

You may have seen a piece of movie sabotage involving the use of a magnet to erase the contents of a hard drive, or you may have simply been told to keep your devices well clear of them, but this danger is largely mythical. For forms of flash memory that use solid state drives, magnetism will have no effect whatsoever, so your laptop, smartphone and USB stick are probably perfectly safe.

For hard disc drives, however, the danger is partially real. These devices create a binary code using polar alignments on the magnetic parts, so a strong enough magnet could alter the polarity and ruin the data. Myth confirmed? Not quite, as the magnet would have to be as strong as an MRI machine to have any impact. So unless your devices are going to be exposed to a super-magnet, they'll be safe.

A magnet as powerful as an MRI scanner could destroy data on a hard disc drive



# "QWERTY IS THE MOST EFFICIENT KEYBOARD LAYOUT AVAILABLE"

Keyboards beginning from the top left with the characters Q-W-E-R-T-Y have become ubiquitous with modern computers. And as many of us find this keyboard style easy to use, it seems appropriate that the alphabet is arranged in this way simply because it's the most efficient. However, the QWERTY layout is actually a relic from the typewriter era.

Originally, typewriters were arranged in alphabetical order, but as commonly used letters were placed next to each other this caused the machine to jam if these letters were struck in close succession, as the bars that pressed against the paper would collide. QWERTY was the answer to this issue, so common keys were placed further apart from one another.

However, the 'Dvorak' and 'Colemak' arrangements are arguably more efficient, as commonly used characters are placed where they can easily be reached. But given you would have to retrain your brain and fingers, most of us will probably continue to stick with QWERTY.



Hard disc drives contain two magnets that control their read/write heads

*"Spotify's shuffle service is not completely random"*





# We put eight of the most persistent science myths under the microscope

## “COIN FLIPS ARE 50:50”

If there's one thing that we know for sure, it's that a series of coin tosses will come out half heads and half tails. Wrong. Coin flips aren't completely independent. True, the coin doesn't know what side it landed on last time, so if you got five heads in a row, you aren't overdue a tails. But the side that faces upwards when you make the flip influences the side it'll land on.

Researchers from Stanford University and University of California, Santa Cruz watched coin flips with a high-speed camera. They found that if you flip a coin head-side up you have a 51 per cent chance of catching it head-side up. And, for some people, the chance can be as high as 60 per cent depending on exactly how they flip the coin. What's more, if you spin the coin, the lightest side will face up more often than the heaviest. This tends to be tails, but it depends on the exact coin you use. The advantage is tiny but well worth knowing about if you're betting on a coin toss.

If you flip a coin head-side up, it's more likely to land head-side up



The first commercial chewing gum was made and sold in 1848 by John B Curtis

Barium can be used to find blockages in the intestine, including swallowed gum

## “IT TAKES SEVEN YEARS TO DIGEST CHEWING GUM”

It can take on average between one to three days for food to go all the way through your digestive system, but legend has it that gum stays in there for seven years! Luckily for any accidental gum swallower, this simply isn't true. So what exactly does happen to chewing gum when we swallow it?

The chewy part of chewing gum is made of tough stuff — a natural or synthetic rubber base that even the digestive system can't break down, able to withstand the stomach's acid and the intestines' digestive enzymes. But most other components, including sweeteners and flavourings, can be broken down. This means the body can deal with it, so the gum will eventually move towards the exit in a few days. If you swallow something smaller than two centimetres in diameter, chances are it'll be able to squeeze out. And gum has the added benefit of being soft.

There have been rare reports of children with gummed-up intestines, but they had swallowed vast quantities of the sticky stuff. Even so, chewing gum has no nutritional benefit, and can be a choking hazard, so you are still advised to spit it out.

## “CRACKING KNUCKLES WILL CAUSE ARTHRITIS”

Knuckle cracking involves pulling apart the joints by stretching or bending them, which decreases the pressure in the fluid between them. This causes dissolved gases in the fluid to form bubbles, which then burst with a characteristic crack. Legend has it that this causes osteoarthritis, where the cartilage covering the ends of the bones becomes thin and roughens. But this legend isn't true.

In 1998, Dr Donald L Unger wrote a letter to the editor of *Arthritis and Rheumatology*. He had been cracking the knuckles of his left hand at least twice a day for 50 years, with his right hand acting as the control. He had compared both hands for evidence of arthritis and found none, but he did confess that his study wasn't enough to debunk the myth.

However, a larger study later appeared in the *Journal of the American Board of Family Medicine*. The team quizzed 215 people aged 50–89 about their knuckle-cracking habits and looked at X-rays of their hands. The result? There was no difference between those who cracked and those who didn't.

### Healthy joint

The joint is surrounded by a capsule of synovial fluid. The bones have a thin layer of cartilage, which acts like a shock absorber.

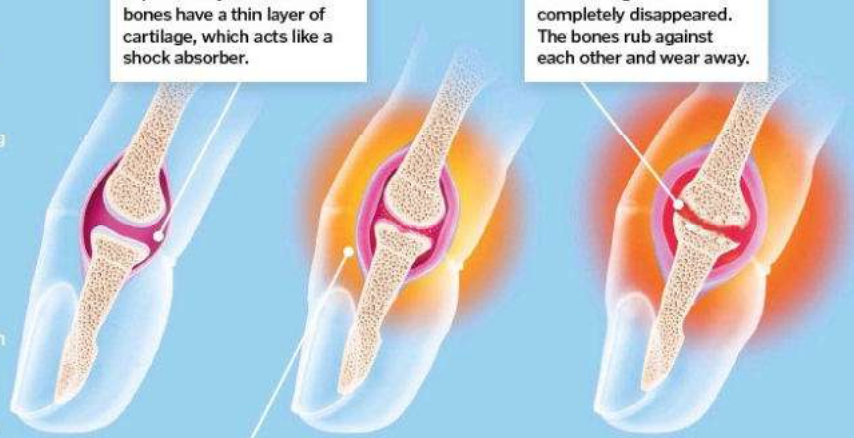
### Erosive osteoarthritis

The cartilage has completely disappeared. The bones rub against each other and wear away.

### Moderate osteoarthritis

The cartilage has become thin and gradually roughens. The synovium makes extra fluid, which causes swelling.

Osteoarthritis is caused by wear to the cartilage that covers the joints





# "YOU ONLY USE TEN PER CENT OF YOUR BRAIN"

While the human species is already pretty smart, could we be even smarter? The old saying goes that we only use ten per cent of our brains. So just imagine what we could do if we kicked the other 90 per cent into gear. Not much more, as it turns out. The ten per cent figure is a myth.

We don't know exactly where the myth came from, but it may have started as a misinterpretation of early experiments on brains. The first cause could be the fact that during brain scans, not all parts of the brain light up, possibly leading early experts to assume that the darker areas were inactive. On top of this, there is the fact that people can survive damage to certain parts of the brain following a trauma such as a stroke.

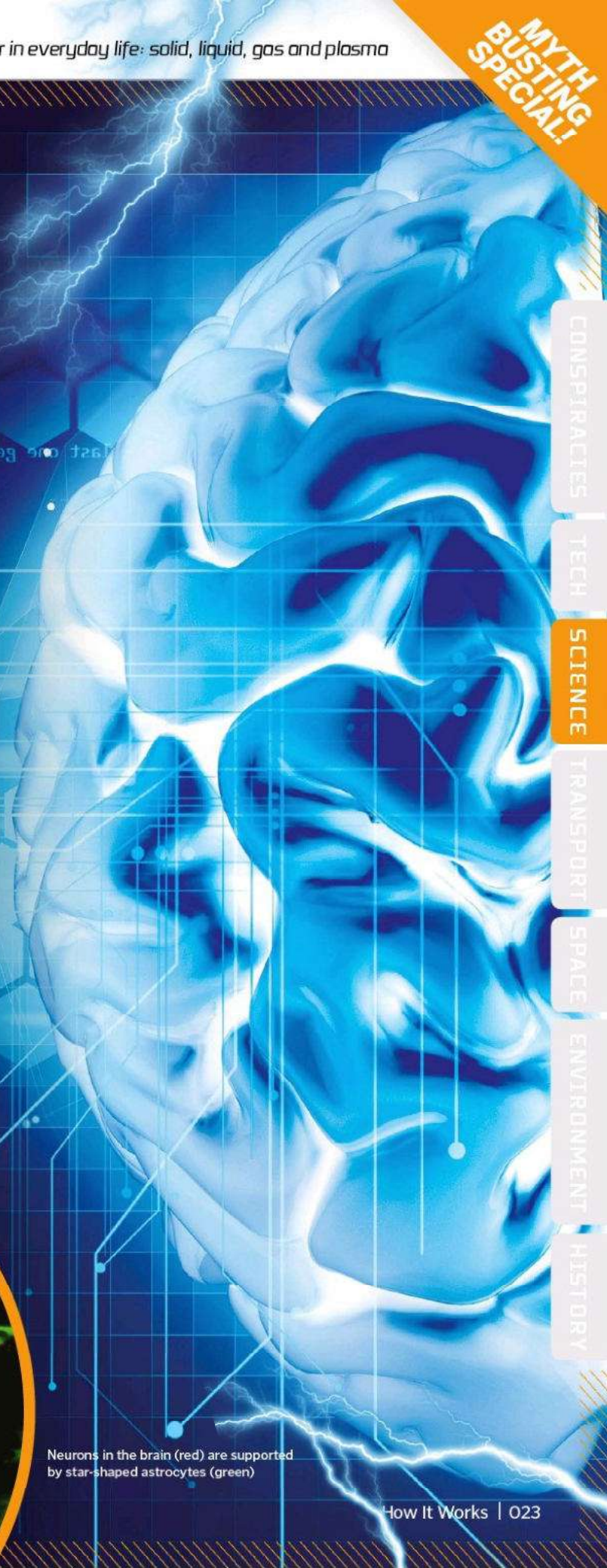
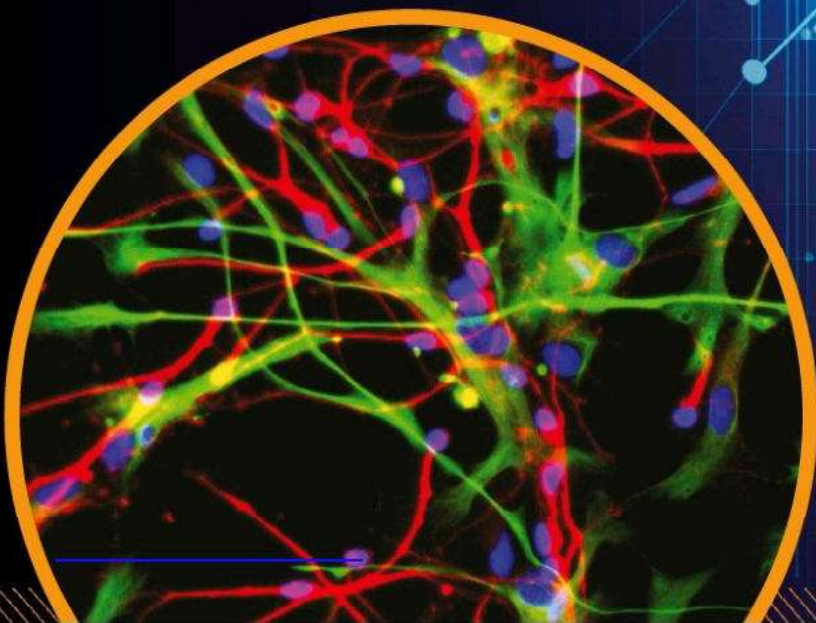
We each have around 86 billion nerve cells, or neurons, in our brains. Each one can have up to 100,000 dendrites, which are branches that help neurons to make connections to each other. Just by reading this page, you're using almost every part of your brain. Your brainstem is taking care of your heart rate and breathing. Your cerebellum is keeping you

balanced. Your occipital lobe is handling the input from your eyes. And your temporal, parietal and frontal lobes are working together to decode the words. All this brain activity, needs energy; up to 20 per cent of the body's total in fact. That's a lot for using just ten per cent of the brain.

If this still isn't enough, around half of your brain isn't made of neurons but glial cells. The word is Greek for 'glue', and these cells sit between the neurons, providing support and protection. Then there are the astroglia, which help maintain chemical balance; oligodendrocytes, which insulate neurons; and the microglia that repair damage, fight infection and clean up debris. These cells are constantly active, blowing the ten per cent figure out of the water.

*"We each  
have around  
86 billion  
nerve cells in  
our brains"*

Neurons in the brain (red) are supported by star-shaped astrocytes (green)







# "A PENNY DROPPED FROM A SKYSCRAPER COULD KILL SOMEONE"

There's no need to fear for your life the next time you pass through the shadow of a skyscraper — pennies dropped from the rooftops aren't going to pierce your skull. Intrepid investigators have put this myth to the test in ingenious ways, and it's been well and truly busted.

University of Virginia physics professor Louis Bloomfield was so confident that the myth was false that he sent a penny-loaded helium balloon into the sky. The pennies dropped like leaves in the air, buffeted by the wind. The faster they fell, the more air resistance they experienced. Pennies are too small and flat to be a danger, only reaching speeds of around 40.2 kilometres per hour. At some point the downward force of gravity balances the upward force of air resistance, and the pennies can't fall any faster.

According to the *Myth Busters* team, a penny dropped from the top of the Empire State Building might collide with the pavement at 103.6 kilometres per hour. So they made a gun that could fire pennies at that speed. Although their test dummy may have suffered a little damage, when they turned on each other they were not harmed. According to Professor Bloomfield, if the coins fell in a vacuum they'd be much more dangerous, reaching a speed of 335.7 kilometres per hour. But even then they wouldn't penetrate the skull.

However, in an interview with *Life's Little Mysteries*, he warned against ballpoint pens. The shape of these is more bullet-like, and if they come down straight they could get close to 335.7 kilometres per hour in the air, so the pointy end could do a lot more damage.

Coins tumble through the air, limiting their top speed



# "SNEEZING WITH YOUR EYES OPEN WOULD MAKE YOUR EYES POP OUT"

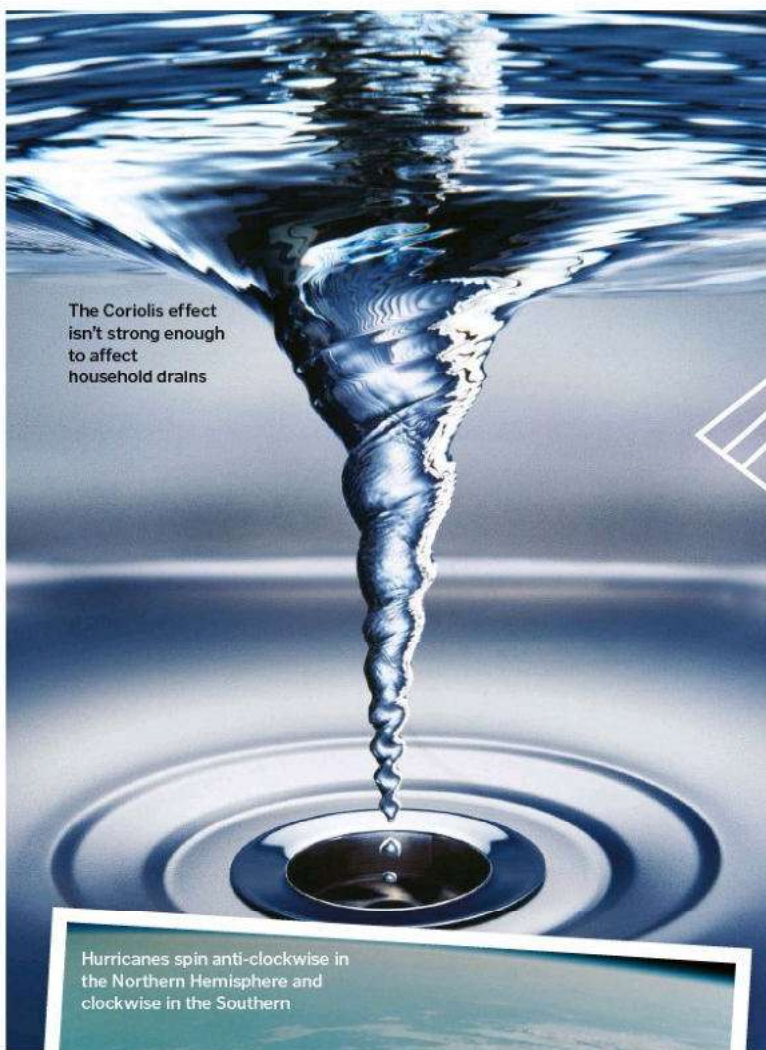
People shut their eyes when they sneeze, but it's not to prevent them from bulging out of their heads. We sneeze to clear irritants from our airways, and closing our eyes stops the same irritants from getting straight back in. It happens automatically, but if you do keep your eyes open it's highly unlikely that anything bad will happen.

In 1882, *The New York Times* reported a burst eyeball following a sneeze, and it's true that straining can rupture blood vessels. A powerful sneeze or excessive coughing can cause a bleed in the eye. These injuries normally heal without any need for treatment, and they can happen whether your eyes are open or closed.

*"We sneeze to clear irritants from our airways"*

The average sneeze travels at a speed of 163.9 kilometres per hour





The Coriolis effect isn't strong enough to affect household drains

## "WATER DRAINS IN THE OPPOSITE ROTATION IN THE SOUTHERN HEMISPHERE"

Earth is always spinning. It rotates from west to east, completing a full turn every 24 hours, and this causes something known as the Coriolis effect. Earth is a sphere, and it's wider at the equator than it is at the poles. Therefore, for the whole planet to spin around in the same amount of time, the ground at the equator has to spin faster than the ground at the poles.

If you were able to stand at the equator and throw a ball northwards towards your friend in the UK, it would appear to curve to the right because they are moving slower and have not caught up,

while you conserve momentum. But if you were in the North Pole and threw a ball towards the UK, again it would curve to the right, but because the UK is moving faster than at the pole, your friends are now ahead of the ball.

Back on terra firma, the effect is that liquids, including those in the air, deflect as they move. You can watch it happening in the spin of hurricanes, which turn in different directions in the Northern and Southern hemispheres. But this effect isn't strong enough to affect water draining from our sinks: the Earth just isn't moving fast enough.



Hurricanes spin anti-clockwise in the Northern Hemisphere and clockwise in the Southern

## "HAIR AND NAILS CONTINUE TO GROW AFTER YOU DIE"

Medical students and morticians might notice cadavers with fresh stubble, but there isn't a mysterious life force inside the follicles. It may look like new cells are growing at the roots, but appearances can be deceiving. After death, the body starts to dry out and, as skin loses moisture, it shrinks. What looks like new growth is just hair and nails that were once hidden underneath being revealed.

Many of our cells do stay alive longer than us. Studies looking at the genes of animals in the four days after they died showed that many cells activated automated stress responses after death. Stem cells in particular fight to survive as long as possible.



Nails look like they're growing because the skin around them shrinks





## From airborne bugs to petrol pump pyrotechnics, we uncover some transport truths

## "THE BERMUDA TRIANGLE IS DANGEROUS"

### The truth is clouded

Meteorologists now think that unusual hexagonal clouds above the triangle create 'air bombs' full of wind that are able to bring down a plane or send a ship to the bottom of the Atlantic.

### An ocean of danger?

The Bermuda Triangle covers roughly 1.3 million square kilometres of ocean off the southeastern tip of Florida.

The Bermuda Triangle is home to many myths surrounding stories that have become distorted over the years

BERMUDA (U.K.)

BAHAMAS

Miami

CUBA

DOMINICAN REPUBLIC

PUERTO RICO (U.S.)

Considering accidents as a percentage of the ships that pass through the Bermuda Triangle, it is no more dangerous than anywhere else

Legend has it that the subtropical Bermuda Triangle region of the western North Atlantic is the site of hundreds of tragic and unexplained disasters. The stories surrounding the fateful disappearance of planes and ships in the area between Miami, Bermuda and Puerto Rico are often centred around the supernatural.

There are fanciful tales describing rifts in space-time sucking in unsuspecting sea-faring travellers, or the area being haunted by the souls of African people enslaved by the British. Some theories have even suggested that aliens might be responsible for the eerie events. However, the truth is much less paranormal.

The foundations of this myth are rooted in the time of Christopher Columbus, who reported witnessing a great flame of fire (likely a meteor) crashing into the ocean as he sailed through the triangle during his first voyage to the New World. Later, in the 20th century, the naval cargo ship USS Cyclops went missing in the Bermuda Triangle, along with the 300 or so people onboard. No remains of the ship or crew were found, and no distress call had been made despite the ship having the equipment to do so.

One of the most mysterious events since then involved the small ship *Witchcraft*. In December 1967, *Witchcraft* hit something apparently minor within 1.6 kilometres of the shore. Calmly, the experienced captain onboard, Dan Burack, said they needed to be towed but it wasn't an emergency, and he'd fire a flare to indicate his position. Assistance arrived within less than 20 minutes, but he was nowhere to be found and neither was his boat or crew. Burack was a cautious yachtsman and had attached a floatation device to make the boat virtually unsinkable, so even if the hull had been ruptured and the boat flooded, part of it would remain above water. Yet no debris was ever found, despite searching over 63,000 square kilometres.

There are countless other stories, some steeped in folklore and more embellished than others. But statistically there have not been more wrecks in this area. That doesn't mean that the Bermuda Triangle is the safest of waters though. It's known that storms, reefs and the Gulf Stream can cause navigational challenges, but these mysterious goings-on are mostly due to the sheer amount of traffic going through, human error and bad weather, plus the heightened publicity given to accidents within the area.



## “PLANES DUMP TOILET WASTE IN FLIGHT”

Visiting an aircraft toilet is generally an unpleasant affair. It's difficult enough to squeeze into the cramped room and navigate onto the seat, without the additional concern of what may be about to be unceremoniously dumped into the sea. There have always been rumours concerning the fate of waste at altitude – that it is to be jettisoned from the aircraft, but it turns out that this is actually impossible to do.

This is because airline toilets use either closed waste systems (which operate in a similar way to a house toilet) or a more modern vacuum waste system. Both store the sewage in holding tanks and require access to a valve on the outside of the plane to be emptied.

However, there are cases where waste has seeped out of an aircraft accidentally because of a leak in the tank. The waste becomes immediately frozen, along with the blue waste treatment liquid. This grisly frozen mixture is known as blue ice. Though generally blue ice will collect on the outside of the aircraft and remain there until the plane has landed, there are occasions where it can come loose.

Thankfully, most will melt and evaporate before hitting the ground, or an unlucky passerby, but occasionally the pungent snowball will remain intact. There have been verified reports of people and property being hit with blue ice, but it has never been intentional.



It is impossible to intentionally dump waste from an airplane mid-flight

CONSPIRACIES

TECH

SCIENCE

TRANSPORT

SPACE

ENVIRONMENT

HISTORY

## “AIRBAGS KILL MORE PEOPLE THAN THEY SAVE”

There's no doubt that airbags save lives by reducing the impact of a crash, but there is still a rumbling of urban myths surrounding these road safety devices. You might have heard that airbags kill more people than they save, but this is incorrect. They generally only cause injury if they're used incorrectly.

The National Highway Traffic Safety Administration estimate that between 1987-2015, a total of 44,869 lives were saved. While, between 1990-2008, more than 290 fatalities had occurred. So, unless you ignore safety guidelines, it is much riskier to drive a car that's not fitted with airbags than one that is.



FO4305OZ02

Together with a seatbelt, airbags are an important safety feature in vehicles





# “MOBILE PHONES CAN BRING A PLANE DOWN”

Have you ever noticed that sometimes, usually just before your phone rings, your speakers start emitting a static sound? That's cellular interference, and it's quite annoying. It's even more annoying if it's being blasted through your headset when you're a member of the flight crew trying to organise irritated passengers while simultaneously preparing to launch an 80-ton plane 12,000 metres into the air.

Not being allowed to use your phone onboard actually has nothing to do with potentially causing a crash: it's more due to the risk of this cellular interference sound distracting flight crew. There is

almost no risk of causing a plane crash because you were using your phone, but aviation authorities understandably choose to err on the side of caution.

Modern aircraft have electronics that are designed to shield them from interference from cellular communication. It's estimated that at least half of all phones are not switched onto flight mode, and there remains no known flight that was adversely affected by this kind of interference. So while you could send those last few Snapchat selfies as your flight takes off, for the sake of the crew, it's probably best not to risk it.



Mobile phones may be annoying on flights, but they won't bring a plane down

# “THE TITANIC WAS KNOWN AS ‘UNSYNKABLE’”

Submerged nearly four kilometres beneath the surface of the icy North Atlantic Ocean lies the red-rusted remains of the magnificent ocean liner the RMS Titanic. This iconic passenger vessel is remembered as the unsinkable ship, but did anyone at the time really believe this to be true? Evidence suggests that while passengers and crew did feel they were aboard an exceptionally safe vessel, there had been no advertising of the liner as being 'unsinkable'.

This phrasing only came from the White Star Line after the Titanic had sunk. When reports of the sinking ship reached America on the morning of the 15 April 1912, Philip Franklin (the vice president of the company) announced, "There is no danger that Titanic will sink. The boat is unsinkable and nothing but inconvenience will be suffered by the passengers."

Previous to the sinking of the Titanic, the only known record of someone saying the ship was unsinkable came from a crew member to calm the nerves of the passenger Mrs Sylvia Caldwell. It's reported he said to her, "God himself could not sink this ship!" The belief that the Titanic was ever seen as the unsinkable ship is a result of latter-day myth making and sensationalism.



The Titanic was never officially described as unsinkable



The ill-fated Titanic had been undisturbed until it was rediscovered in 1985



It might not seem like a nice thought, but the air on a plane is actually cleaner than the air in your office

## “RECIRCULATED AIR INSIDE PLANES SPREADS DISEASE”

Nothing says uncomfortable like being trapped inside a confined space with only questionable airplane food and the thought that you're breathing the same continuously recirculated air for the next few hours. You become very aware of the amount of people who are coughing, sneezing and spluttering their way through the aircraft, convinced you will quickly succumb to the sniffles.

It might feel like you're breathing in air saturated with germs, but modern aircraft now have exceptionally powerful systems that use HEPA filters to catch up to 99.97 per cent of airborne microbes. The air is also filtered and recirculated approximately once every two to four minutes. In fact, it's probably cleaner than the air in your office, which is usually only refreshed about 12 times an hour.

The supply of fresh air in a plane isn't lacking either, with 50 per cent of the cabin supply being crisp air from outside. This air is drawn into the plane continuously via compressor stages in the jet's engines. So the next time you're on a flight, while there might not be much you can do about the person kicking your seat, at least you can breathe easy about the air quality.

## “USING YOUR PHONE AT THE PETROL STATION COULD CAUSE AN EXPLOSION”

Mobile phones have been held accountable for causing horrific accidents, but much like the stories of crashing planes, exploding petrol stations are also a myth. There is absolutely no scientific evidence to suggest that emitted radiation from a mobile phone can ignite gasoline vapours, but the rumour was propagated with the best of intentions.

Phone manufacturers started this by printing warnings about phone use near gasoline in user manuals, and in response to this, oil companies reacted with caution, with both industries working together to enforce

Using your mobile phone at a petrol station will not cause it to explode



something they felt would protect people. But, once evidence had come to light to disprove the fire theory, petrol stations that chose to keep the 'phones off' rule did so because they're an unwanted distraction, rather than a danger.



Despite having over 2,200 people onboard, the Titanic only carried 20 lifeboats



A fire in the boiler room before launch is thought to have weakened the ship's hull







## We pick apart some of the most common misconceptions in the cosmos



Asteroids very rarely collide in space, but it's probably spectacular when they do



Travelling through the asteroid belt would not be as exciting as you might think

## “THE ASTEROID BELT IS FULL OF ASTEROIDS”

Blame *Star Wars* for this one. In *The Empire Strikes Back*, Han and co weave their way through an asteroid belt in the Millennium Falcon, dodging flying rocks all over the place, against the odds. It was a great scene, sure, but the science was lacking. The problem is that asteroids just aren't that close together. They're really, really far apart, and flying between them would be a breeze. In the asteroid belt between the orbits of Mars and Jupiter, you'd be hard-pressed to even see one asteroid from the surface of another.

Scientists estimate the main asteroid belt contains between 1.1 and 1.9 million asteroids larger than one kilometre in diameter, and millions of smaller ones. Most known asteroids orbit in this main region, and on average each sizeable asteroid is at least several million kilometres away from another, with the chances of a collision being about one in 1 billion. Could we assume that in a galaxy far, far away, they've found an asteroid belt that's much more tightly packed? Absolutely. But in ours, this scene would have been a lot less exciting.

The sensation of being in space can make it feel like there's no gravity



## “THERE'S ZERO GRAVITY IN ORBIT”

Perhaps the most common misconception about space concerns what space actually is. A lot of people seem to think that when you launch a rocket straight upwards, you eventually reach a point where you start floating. That's why the astronauts on the International Space Station (ISS) appear weightless, right?

Well, we're afraid that's just not true. The reason astronauts on the ISS appear to be floating is because they're in constant free fall towards Earth. In the late 17th century, Isaac Newton first published his thought experiment to demonstrate his concept. He suggested that if you fired a cannonball horizontally from the surface of Earth — at greater and greater speeds — the ball would not hit the Earth but instead orbit the planet. That's basically what's happening on the ISS. They're moving so fast (over 28,000 kilometres per hour) that they constantly fall towards the Earth. As a result, they're in constant free fall and appear to experience weightlessness.

In fact, at an altitude ranging between 370–460 kilometres above the Earth's surface, the ISS still experiences 90 per cent of Earth's gravity. Everything in orbit

experiences the pull of our planet, it's just that they move so fast sideways that it seems like they are weightless. So, the next time you see footage of astronauts floating around, just remember they're not in zero gravity. They're actually constantly falling, but thanks to the extremely low friction of the upper atmosphere, their spacecraft never slows down, so they never fall to Earth.



Astronauts on the ISS can have a great time in the microgravity environment



# "BLACK HOLES SUCK EVERYTHING IN"

Contrary to popular belief, black holes are not cosmic vacuum cleaners that suck up everything in their vicinity. In fact, they behave not that differently from a star at first. It's when you get close that things start to get weird.

First, let's back up. A black hole forms when the centre of a massive star goes supernova, leaving behind a dense core that collapses in on itself. These are known as stellar mass black holes and, as their name suggests, they're actually quite similar in mass to a star. If the Sun was substituted by a black hole of equal mass, all the planets currently orbiting the Sun would continue on their orbits as they are now and would not instantly be pulled in. But the Sun is not massive enough to ever evolve into a black hole.

At the heart of our galaxy is a supermassive black hole, known as Sagittarius A\*, and we see these at the centre of almost every massive galaxy. Again, these black holes clearly don't suck everything in. Some, in more distant galaxies, are surrounded by a quasar — a superheated accretion disc of gas and dust — and some can fire jets.

But there is a point beyond which black holes behave quite strangely. At the edge of its inner core, which can be just a few kilometres across, you'll find the event horizon. This is where the gravitational pull is so intense that nothing — not even light — can escape. At this point, you could probably say that the black hole was sucking you in. What happens next is anyone's guess, however, because what goes in never comes out.

Try and stay inside your spacesuit if you can

## "YOU'D EXPLODE WITHOUT A SPACESUIT"

Contrary to what some films might have you believe, taking your suit off in space won't cause you to immediately explode. Yes, your outlook isn't great, but it might not be as dramatic as some think. The first thing that would happen is you'd lose consciousness after about 15 seconds due to a lack of oxygen after your body has used up the oxygen in your blood. Before this happens, you would have needed to breathe out as much air from your lungs as possible, otherwise that oxygen will rupture your lung tissue.

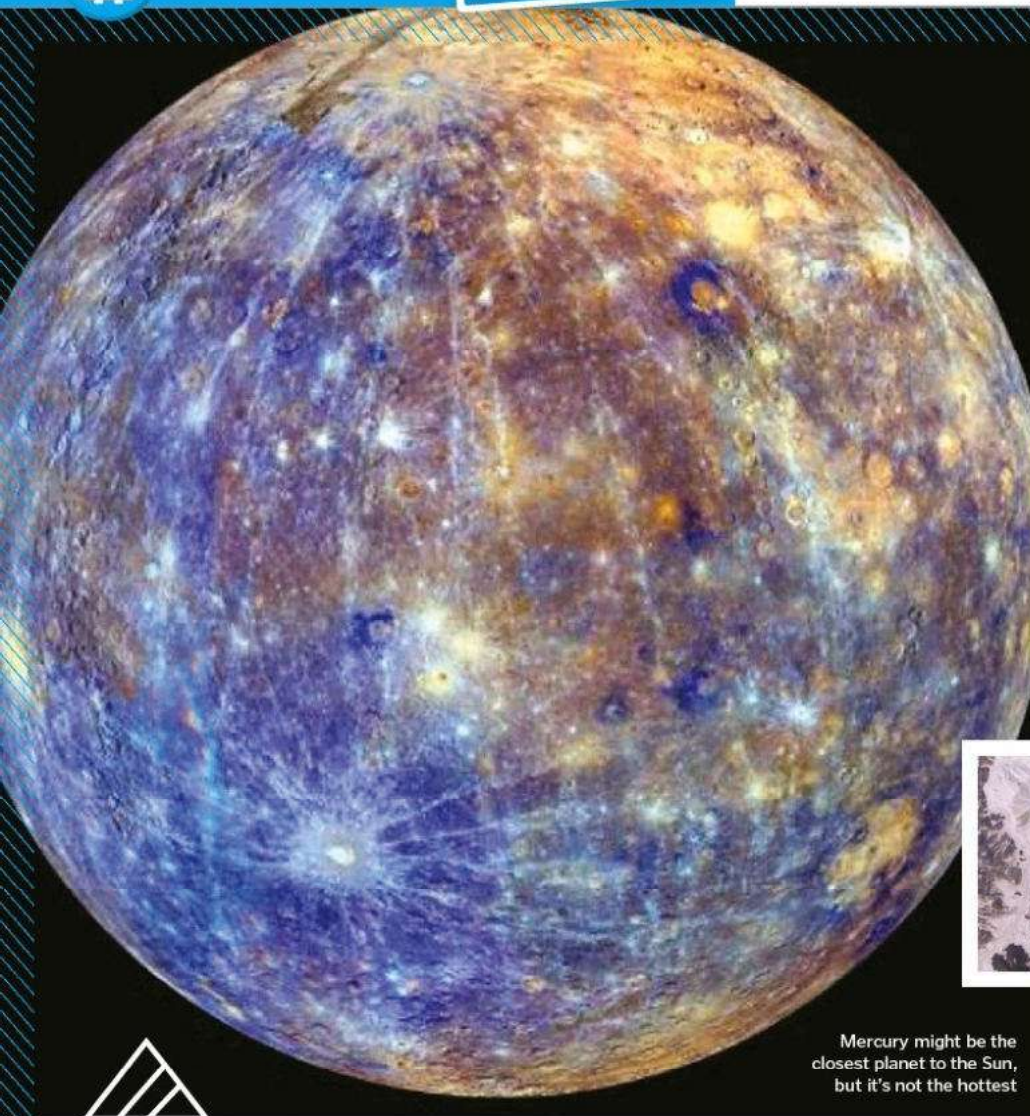
Next up you've got ebullism, where the drop in pressure (spacesuits are like mini spacecraft, remember) causes gas bubbles to form inside your body fluids. A test subject accidentally exposed to a vacuum in 1965 reported that he also started to feel saliva on his tongue boiling due to the drop in pressure. So after a few minutes you'd be in pretty serious trouble, and while you might not explode, you probably don't want to stay outside for too long.

Black holes aren't as dangerous and deadly as is commonly thought

Supermassive black holes are thought to be at the centre of nearly every large galaxy

"Black holes are not cosmic vacuum cleaners"





Mercury might be the closest planet to the Sun, but it's not the hottest

## “MERCURY IS THE HOTTEST PLANET”

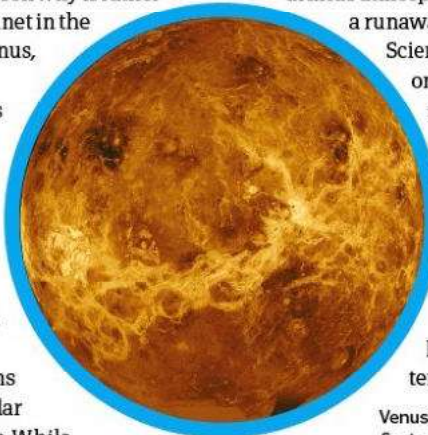
Mercury is the closest planet to the Sun, so surely it should be the hottest planet, right? Well, not quite, and the reason why is rather interesting. The hottest planet in the Solar System is actually Venus, with an average surface temperature of 462 degrees Celsius. But, Mercury reaches highs of 'only' 427 degrees Celsius.

The reason for this difference is that Venus, unlike Mercury, has a thick atmosphere. Instead, Mercury possesses a thin exosphere made up of atoms blasted off its surface by solar wind and micrometeoroids. While

Mercury heats up in direct sunlight, things get hotter on Venus, where the mainly carbon dioxide atmosphere traps the Sun's heat in a runaway greenhouse effect.

Scientists think that Venus may once have actually had shallow-liquid water oceans and habitable surface temperatures, but exposure to sunlight caused the ocean to evaporate, and with no water vapour remaining, the planet's atmosphere has thickened and its temperatures have risen.

Venus is the hottest planet in our Solar System thanks to its thick atmosphere



## “THE GREAT WALL OF CHINA IS VISIBLE FROM SPACE”

More specifically, this myth claims that the Great Wall of China is the only human-made object visible from space. We're sorry to burst your bubble but this simply isn't true, although it does depend on what you count as space. Even from low-Earth orbit (around 160 kilometres up), the wall is not visible to the naked eye. It's just too thin, and the colours don't stand out much from the surrounding landscape. On the ISS, it is barely visible using a camera, and even then only under perfect conditions, but it is certainly not visible from the Moon.

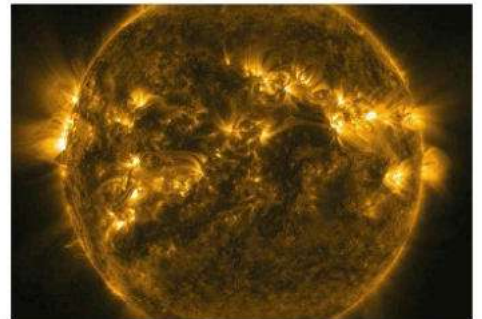
However, you can see other evidence of humanity from the ISS with the naked eye, such as cities in the day and night, as well as airports, dams, bridges and even the pyramids. The official boundary of space is 100 kilometres up, but even from here you'd struggle to see the five-to-ten-meter-wide Great Wall unaided.



The Great Wall is extremely long but not that wide and thus very hard to spot

## “THE SUN IS YELLOW”

Think the Sun is yellow? Think again... sort of. The Sun emits all wavelengths of visible light, from violet to red. This means that it would appear white if you could view it with the naked eye in space. However, each colour corresponds to a different temperature, with yellow-green light of 550 nanometres emanating from about 5,700 degrees Celsius. From Earth the Sun appears yellow because the longer-wavelength yellow light is less easily scattered by our atmosphere than shorter-wavelength colours like blue and violet.



The Sun might seem yellow to us, but appearances can be deceiving



# “THE MOON HAS A DARK SIDE”

It might seem like the Moon has a dark side, but actually the Moon has cycles just like Earth does. The reason this myth pervades is because from Earth we can only see one side of the Moon as it's gravitationally (or tidally) locked to our planet.

There is a far side of the Moon that we never see, but in its 27.3-day orbit around Earth, the Moon goes through day and night cycles like our planet. This is why we see it change in brightness from being full to a crescent; the Sun is shining on different parts of the Moon from our perspective, but there's no dark side — only a side that we cannot see.

*“The Moon goes through day and night cycles”*

CONSPIRACIES

TECH

SCIENCE

TRANSPORT

SPACE

ENVIRONMENT

HISTORY

There is a far side of the Moon (left), but there's no dark side





*Homo habilis* made and used the first stone tools

## We unravel some common misconceptions about the natural world

# “HUMANS EVOLVED FROM CHIMPANZEES”

Although there are similarities between humans and chimpanzees, such as opposable thumbs and facial features, but chimps didn't just shed their fur and start making fires. We are, however, genetically related to chimps through our common ancestors, along with other great apes like gorillas and bonobos.

The first sign of primates on Earth dates back to around 55 million years ago (MYA). Then, from a common ancestor, chimps and humans split into two distinct genetic timelines between 8–6 MYA, although a more recent study suggests that divergence may have occurred up to 13 MYA. Our primate cousins continued to evolve into the apes we see today, whereas others evolved into the group known as Hominini, of which we are the only surviving species.

Chimpanzees remained in the group Hominoidea, which divides over 20 species between great apes such as orangutans and lesser apes such as gibbons.

It was around 5.8 MYA that one of our proposed ancestors—*Orrorin tugenensis*—walked on two legs, despite closely resembling a chimpanzee. About 4 MYA, our prehistoric species developed a brain more representative of the *Homo sapiens* we are today — these more advanced ancestors were *Australopithecus afarensis*. Our use of tools dates back some 2.6 MYA, regularly used by *Homo habilis* and *Homo erectus*, who around 1.8 MYA, was the first to stand up straight.

Though we started our evolutionary journey together, chimps and humans evolved alongside one another rather than us descending from them.

“Chimps and humans evolved alongside one another, rather than us descending from them”



Chimps are among our closest living relatives, but they are not our ancestors



The word 'diamond' is derived from the Greek word 'adamas', meaning invincible or indestructible

#### Strong bonds

Each carbon atom inside a diamond is covalently bonded to four other carbon atoms.

## "DIAMONDS ARE MADE FROM COAL"

It is often thought that diamonds form from the compression of coal, but these beautiful gems originate from a deeper geology. The confusion comes from their similarly high content of carbon. Both diamonds and coal are made of carbon, but they form in different layers within the Earth.

Diamonds form in the Earth's mantle, around 145 kilometres below the surface. At temperatures of around 1,050 degrees Celsius, diamonds form from carbon under the immense pressure of the Earth's mantle. Ejected via volcanic eruptions, diamonds are pushed to the surface, hitching a ride on a magma channel rising from the mantle.

Diamonds have also been known to come from the subduction zone, where an oceanic plate collides with a continental plate, forcing the oceanic plate underneath its continental counterpart. This process occurs at a lower temperature and pressure, so smaller diamonds are formed.

On the other hand, as a sedimentary rock, coal is the product of the decomposition of natural materials such as sea life and plant material. Coal is formed much higher up in the mantle, and is rarely buried to depths greater than 3.2 kilometres. Though it would make a great rags to riches story, in the case of diamonds, it's riches all the way.

Once cut and polished, diamonds present their unique sparkle



#### Under pressure

Created under intense pressure and heat, diamonds are the hardest natural mineral.

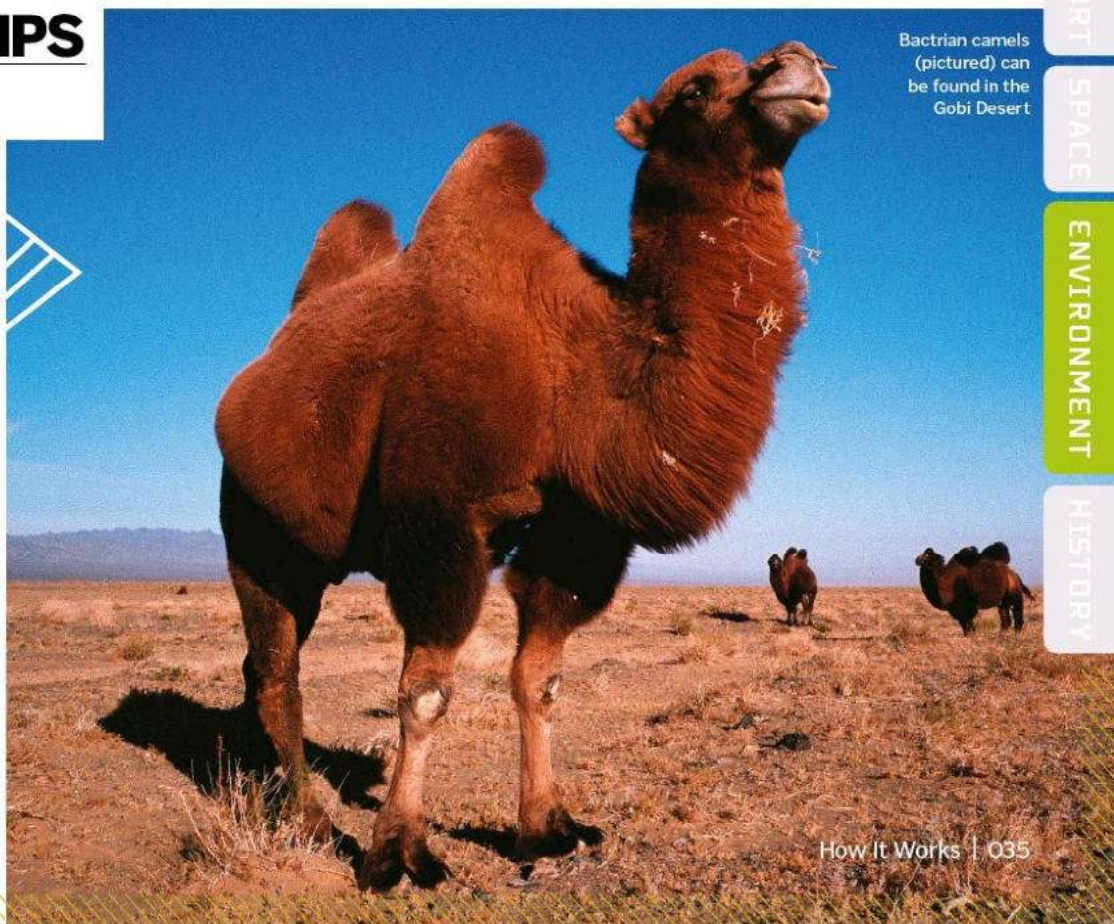
## "CAMELS' HUMPS ARE FILLED WITH WATER"

In order to survive the intense heat of the desert climate, one or two giant biological water bottles sounds like a great idea. But the idea of a camels' hydrating humps are just a myth, but a myth not far from the truth. Rather than being filled with water, camels' humps are filled with fat.

Similar to the lack of water, deserts aren't known for their lush green vegetation. These mobile mounds of fat stores offer energy for camels to make use of when food is scarce. The longer the time between meals, the more deflated these humps appear as their resources are being used up. This isn't to say that camels don't consume a lot of water; they just don't store it in their humps. When arriving at a watery oasis, the two-humped Bactrian camel, for example, can drink over 100 litres of water in one go.

But, camels do have biological adaptations to optimise water storage. For example, camels' faeces is dry, they have little urine output and are able to fluctuate their body temperature to reduce levels of sweat. So, while their humps aren't filled with water, they have made the changes needed to survive in the harsh climate of the desert.

Bactrian camels (pictured) can be found in the Gobi Desert





## “CLOUDS ARE LIGHTWEIGHT”

Like cotton wool, clouds are always used to describe the lighter things in life. But while they may glide gracefully around a blue sky, clouds are the heavyweight giants of our atmosphere. When you consider the amount of water that comes from a massive downpour, imagine how heavy the cloud must have been to hold it.

The water density of an average fluffy cumulus cloud is about 0.5 grams per cubic metre. If you propose a cloud that is one kilometre long, tall and wide, that gives you a total of 1 billion cubic metres in volume. That works out at around 500 tons of water — the same as around two and half blue whales floating above our heads! This method also suggests that larger and denser cumulonimbus clouds could weigh around 1 million tons! It's a huge weight, but the surrounding atmosphere is denser than the cloud, so it floats. Temperature also plays a part in keeping these clouds in the air, as warmer air is less dense than cool.

As we know, when a cloud gets too full of water, droplets form and we get rain, and the weight of the cloud reduces as a result. So next time it's a cloudy day and pouring it down, there could be literally tons of water falling over your head.

There are ten main groups of cloud that cross the sky



## “GOLDFISH HAVE THREE-SECOND MEMORIES”

‘You’ve got the memory of a goldfish’ is something often heard over your shoulder while you’re hunting for a bundle of misplaced keys. This myth began when humans decided to take these orange iridescent fish as pets. Some think that the myth originated as a justification for keeping fish in small tanks. By the time they had done one lap of the bowl it would be a new experience going around the second, then the third time, and so on.

However, studies have shown this to be untrue. Research has revealed that goldfish can remember food locations and even the people who feed them. Just think, when you go to feed your goldfish, do they come up to greet you? One study by The Technion – Israel Institute of Technology conducted a fascinating study to test out this myth.

The research team trained captive fish to associate a particular sound with that of feeding time. They continued this for a month before releasing them into the wild. The fish were left in the wild for five months, the sound was then played again and the fish that remembered the association between the sound and food came back. So the next time you lose your keys, try asking the goldfish.

Bananas grow in what are known as ‘hands’



## “BANANAS ARE A FRUIT”

It's another ‘is a tomato a fruit or a vegetable?’ debate. Botanically, a fruit is defined as a seed-bearing structure that develops from the flowering plants of a woody tree or bush. The evolutionary purpose for this structure is to entice animals to eat the juicy sweet or sour fruit, helping to spread the seeds in their waste, thereby helping plants reproduce.

The humble banana, however, does not encapsulate its seeds around a fleshy fruit. Instead, the small black seeds (the little dots in the middle) are within the banana's flesh, making it more of a berry, which they would be classified as if their seeds were fertile. Since bananas have been commercially grown the seeds do not mature, and the ‘tree’ a banana grows on doesn't contain true woody tissue, making them a simple herb.

Goldfish are able to identify a familiar face among 44 strangers





# "LIGHTNING NEVER STRIKES IN THE SAME PLACE TWICE"

In the US there are  
around 30 fatalities  
due to lightning  
strikes each year

It's a common myth that if you stand where a lightning bolt just struck then you're safe. It appears that probability is the driving force behind this potentially dangerous myth, but there is a higher chance to be struck twice than you'd think.

In order for a lightning bolt to hit the ground, a discharge of pent up electrical energy within the cloud travels through ionised air. In a matter of milliseconds, the strike reverberates, meaning multiple strikes occur during what appears to be singular event. As this is a cloud-to-ground event, the closer objects on the Earth's surface are to the cloud, the more likely they are to be struck. Take the Empire State Building, for example, which gets hit an average of 23 times a year. Fortunately, it is equipped with lightning rods to help ground the charge in order to keep everyone inside safe.

## 1. A perfect storm

The movement of water and ice droplets within clouds can create charge separation. As rising droplets collide with falling ice or sleet particles, electrons can get knocked off of the rising moisture.

## 2. Charge separation

These collisions lead to the separation of charge within the cloud, with negatively charged ions at the base and the positively charged rising moisture at the top.

## Multiple types

In order for lightning to be generated, positive and negative ions must be separated. It can occur as cloud-to-ground, cloud-to-cloud, cloud-to-air and intra-cloud.

## 3. Repulsion

If the charge separation builds to a sufficient level, the negative charge of the cloud base becomes strong enough to repel negative electrons in the ground, inducing a positive charge on the surface below.

## 4. Neutralise the charge

The opposing positive and negative charges seek to neutralise one another. When the difference in charge gets too high, the surrounding air becomes ionised (separated into electrons and positive ions), helping electrons to move more easily.

## 5. Lightning strikes

The ionised air creates a path between the cloud and the ground which electrons can travel through. This leads to a rapid discharge of electricity, which we see as lightning.





**Not everything  
you've read  
about in the  
history books is  
entirely true...**



## **“KNIGHTS HAD TO BE HOISTED ONTO THEIR HORSES”**

Although they look incredibly heavy, 15th century suits of armour weigh in at around 14–23 kilograms. Despite this, they were not difficult to move about in or mount a horse while wearing. Knights had to remain as agile as possible in order to stay combat effective, or even just survive a melee. If armour really had been so heavy that a fallen knight could not have stood up again on his own, or been able to re-mount his horse, the smallest trip in battle would have been a death sentence.

While the metal plates had to be tough enough for ample protection, they also had to be light enough for prolonged action and a range of

movement. A suit of plate armour could be comprised of around 18 main separate pieces, each protecting a different limb or vital organ. Importantly, each piece had to move flexibly with the wearer, and without restricting any movement such as a sword swing or even some light running.

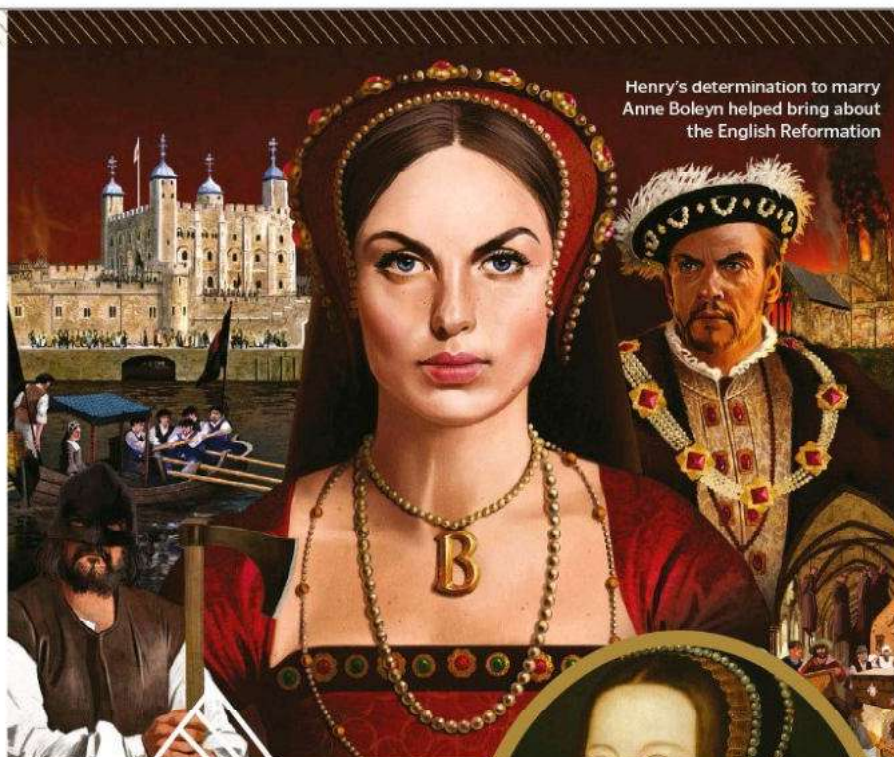
One of the origins of the impossibly heavy armour is found in the 1944 film *Henry V*, produced by Laurence Olivier. This depicts knights being hoisted onto their mounts using cranes — a bizarre fiction with no historical evidence. By contrast, there are historical accounts of armoured soldiers performing

almost acrobatic feats, including Bertrand du Guesclin, who is recorded leaping to and from his horse.

Modern-day soldiers, by comparison, regularly take more than 50 kilograms of armour, weaponry and equipment into combat, the majority of which is carried in their backpacks. With a suit of armour, the weight is spread mostly evenly over the wearer's entire body, making it much easier to bear and balance while wearing. This means that far from being restricted by impossibly heavy armour, knights fighting centuries ago were arguably more light and agile than their 21st-century counterparts.

Armour grew progressively thicker in later centuries to protect against the threat of firearms





Henry's determination to marry Anne Boleyn helped bring about the English Reformation

## "ANNE BOLEYN HAD AN EXTRA FINGER"

Famous for being the doomed second wife of Henry VIII, Anne Boleyn was charged with adultery, incest and high treason. She had faced many accusations, but having an extra finger wasn't one of them. In fact, the claim wasn't even made during her lifetime.

Decades after Boleyn's death, a Catholic propagandist called Nicholas Sander wrote that she had "a projecting tooth under the upper lip, and on her right hand, six fingers". He added that she had a large wart under her chin. In Tudor England physical imperfections were thought to be a sign of evil, and Sander had portrayed Boleyn as a witch who had seduced the king. But would such an unsightly woman have captured the heart of the Tudor tyrant? It seems very unlikely, for so determined was Henry to marry her that he broke away from the

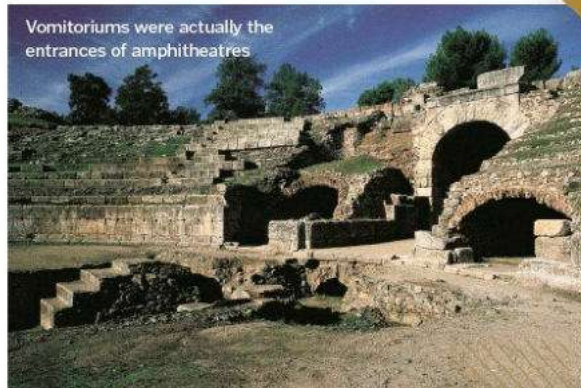
Most paintings of the controversial queen were destroyed after her death

Catholic Church and established his own – the Church of England.

Nicholas Sander never actually met Boleyn in person and was only a boy when she was beheaded in 1536. It's likely Anne's rumoured disfigurements were a way of discrediting her daughter, Queen Elizabeth I. It was her religious policies that forced Sander into exile, and he wasn't alone in attacking the Protestant monarch's parentage in a vengeful bid to sully her name.

What's more, Anne's first biographer, George Wyatt, had spoken to those who knew her and admitted that while she did have several moles and an extra nail on her little finger, there was no sixth digit. And when a body believed to have been Boleyn was exhumed at the Tower of London in the 19th century, there was no evidence to support Sander's slander.

Vomitoriums were actually the entrances of amphitheatres



## "VOMITORIUMS WERE USED FOR THROWING UP IN"

The Romans were fond of a feast. They would gorge on delicacies like wild boar, pheasant, lobsters and songbirds until they couldn't eat any more. That's when they would take a trip to the vomitorium – a room where the diner could expel their previous courses and return to eat some more. Or so pop culture would have us believe.

In ancient Rome, vomitoriums were actually the entrance and exit passages of amphitheatres. The 5th-century writer Macrobius chose this charming Latin word because of the way people 'spewed forth' into their seats at these open-air venues.

It seems people may have got confused over time, which isn't surprising given the infamous gluttony of Rome's emperors. Claudius was said to always finish a meal bloated and confined to bed, while Vitellius allegedly ate the sacrificial meat from an altar! But even emperors didn't have a special chunder chamber.



Marie Antoinette being led to her execution on 16 October 1793

## "MARIE ANTOINETTE SAID 'LET THEM EAT CAKE'"

When the wife of King Louis XVI was told her French subjects had no bread to eat, she retorted, "Let them eat cake." Or did she? It was 1789, crop failures had left the starving population deeply resentful of the monarchy, and the Austrian-born queen became their target. However, the phrase 'let them eat cake' had been used for years. More than a century earlier, Marie-Thérèse – the Spanish bride of King Louis XIV – supposedly said the French people should eat "the crust of the pâté".

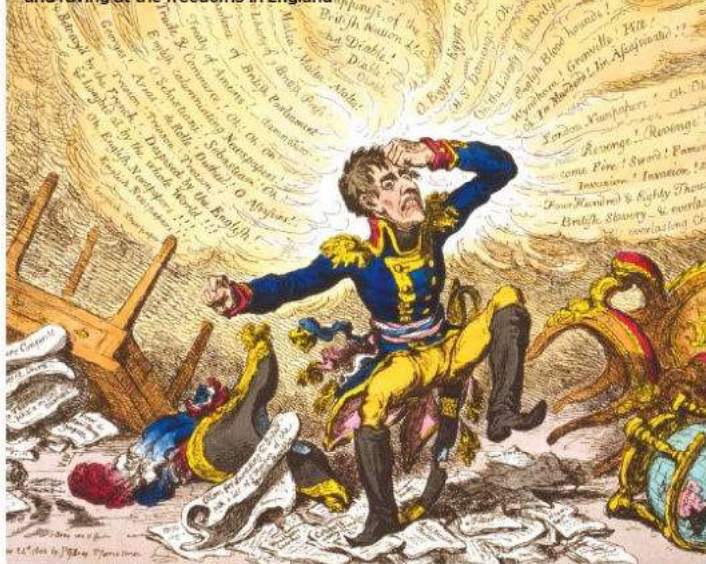
The infamous remark stuck though, and Marie Antoinette's reputation for decadence was blamed for causing the country's economic downturn. While it's true that she embraced life at Versailles, her love of palace parties, fashion and gambling wasn't the cause of the French Revolution. Nevertheless, the misunderstood monarch was sentenced to death along with the rest of the royal family, but the myth survived her.





RAVINGS of the 'little BONEY' in a strong fit

This cartoon of Napoleon by artist James Gillray shows the 'little' emperor ranting and raving at the freedoms in England



## “NAPOLEON WAS SHORT”



Despite conquering much of Europe single-handedly, Napoleon Bonaparte is almost as well known for his short stature. But, in reality the emperor of France was around five foot, 6.5 inches (1.69 metres) tall, making him above average height for men in both France and England at that time.

When he died in 1821, Napoleon was measured to be five foot, 2 inches (1.57 metres) tall. Unfortunately for the deceased, this was taken in French feet and inches, which were slightly larger than English measurements. In the early 19th century the metric system was not yet used universally, meaning there was no standardised measurement. When interpreted as English feet, Napoleon's height was therefore mistakenly recorded as being over four inches shorter.

However, even before his death the emperor had been mocked for his supposed tiny size. Another source of

this myth is found in the British press of the period. Newspaper columns roundly criticised Napoleon, printing caricatures depicting him as a tiny child throwing temper tantrums. This impression was aided by his nickname 'Le Petit Caporal' (the little corporal) among his troops, and the fact his personal bodyguard, the Old Guard, had a minimum height requirement of six feet (1.8 metres), towering above him by comparison.

This myth has proven so persuasive that a theoretical condition was named after the emperor's supposedly short stature. The 'Napoleon complex' suggests that shorter-than-average men become more aggressive, seek more attention in social gatherings and possess greater ambition than average-height or tall men. Experts still question the accuracy of this, but what's certain is that Napoleon was by no means vertically challenged.

## “300 SPARTANS ALONE FOUGHT THE PERSIAN ARMY AT THERMOPYLAE”

In 480 BCE King Leonidas made a brave last stand against a horde of enemies at the head of only 300 of his ferocious hoplite warriors. It is one of the most compelling stories of ancient Greece, but is it entirely true?

In reality, between 6,000–7,000 fellow Greeks joined the Spartans at the Battle of Thermopylae, travelling from across Greece to defend against the Persian invasion led by King Xerxes I. Among those fighting with the 300 Spartans, Herodotus lists 700 Thespians, 400 Thebans, 1,120 Arcadians, 1,000 Phocians, and more. Nonetheless, the Greeks were still greatly outnumbered against up to 100,000 Persian soldiers.

The Greek army was deployed in a narrow coastal pass, nicknamed the Hot Gate, where the overwhelming numbers of attacking Persians could not be effected. According to Herodotus, the crucial turning point in the battle came when the Persian army was led to a secret mountain

pass, enabling them to overcome the Phocian guards.

In the 2006 film *300*, it is at this point that the Spartans' allies abandon them out of fear, while Leonidas declares he and his men will stay and fight to the death. However, even this scene is inaccurate, as several of the Greek allies remained fighting to the bitter end, including those forces from Thespiea and Thebes.

While the Thespians reportedly stayed willingly with Leonidas, Herodotus writes that the king kept the Theban troops against their will. Regardless, the Persian army eventually crushed their Greek opponents, who had fought their way into legend.



King Leonidas died at Thermopylae along with his 300 Spartan hoplites and their allies





Experts believe Vikings wore protective skullcaps made from metal or leather

Vikings were colonists who left their mark on many countries across Europe

## “VIKINGS WORE HORNED HELMETS”

Vikings were seafaring Scandinavians that raided, traded and garnered a bloodthirsty reputation between the 8th to 11th centuries. The famous beastly horned helmets seem to fit the stereotype, but there's actually no evidence to suggest they ever wore them.

This myth was popularised after writers and artists used the headgear in their portrayals of Vikings. In the 1870s, German costume designer Carl Emil Doepler, created horned helmets for Wagner's Norse-inspired opera, and is often credited with cementing this stereotype. Perhaps these creators were inspired by

19th-century archaeological discoveries of horned helmets — but these were later found to predate the Vikings.

The only shred of evidence that can be called 'Viking' was discovered at a Gjermundbu burial mound, but this 10th-century artifact does not have any horns. It's possible such helmets were used for ceremonial purposes, but it's very unlikely they were worn aboard warships — the space would have been too limited — and they wouldn't be practical in battle either. Instead, it's thought that Norsemen wore leather skullcaps or domed metal helmets with brow

ridges, fragments of which have been discovered. It could also be possible that some Vikings didn't wear any headgear at all, which would explain why only a small number of helmets have been found.

That's not the only myth surrounding the Vikings though. Portrayed as bearded, illiterate savages, we've since discovered they groomed themselves with combs and razors; they developed a complex alphabet of runes; and while some spilled a lot of blood in their bid to conquer foreign lands, others earned a peaceful living through farming and trading.



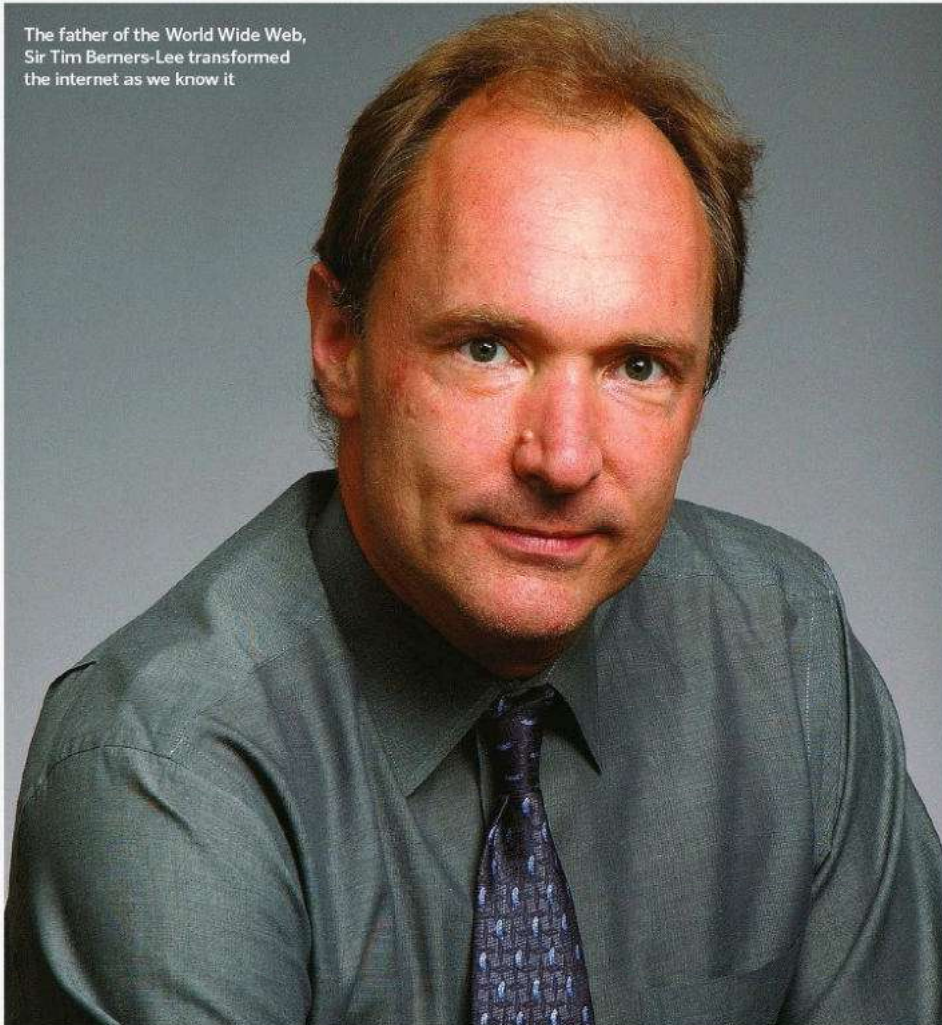


## HEROES OF... TECHNOLOGY

# Sir Tim Berners-Lee

The revolutionary computer scientist who invented the World Wide Web

The father of the World Wide Web, Sir Tim Berners-Lee transformed the internet as we know it



**B**orn in June 1955 in London, Sir Timothy Berners-Lee's pioneering work has transformed every aspect of our lives; he is the creator of one of the greatest inventions of the 20th century. Berners-Lee was not the first in his family to master mathematics; his parents Conway Berners-Lee and Mary Lee Woods also dedicated their lives to the subject. His passion for science led him to attend Oxford University, where in 1976 he graduated with a first-class degree in physics.

After completing his degree, Berners-Lee moved on to become a scientist at CERN, the European Organization for Nuclear Research, in 1989. That same year, Berners-Lee published a paper titled *Information Management: A Proposal*, in which he suggested the combination of hypertext and the internet for an information management system.

In this initial proposal for the World Wide Web, Berners-Lee described the shortcomings of the then-current system at CERN in allowing scientists access to their information and documentation. Though the internet had been around for a decade, the information had limited accessibility. Berners-Lee set out to connect both the internet and a web-structured platform to revolutionise data sharing. To achieve this he created the Hypertext Transfer Protocol (HTTP), Uniform Resource Identifier (URI) and Hypertext Markup Language (HTML), the building blocks for internet browsing that remain in use today.

Created to better serve CERN scientists and assist those across the globe with their research, Berners-Lee launched the first website, <http://info.cern.ch>, in 1990. This new way to obtain information was something Berners-Lee wanted the entire world to have access to. He decided to make the World Wide Web an open and royalty-free software, allowing it to grow beyond academia. By 1994 there were around 3,000 websites in existence; today there are over 1 billion. After such a roaring success, Berners-Lee created W3C (World Wide Web Consortium), a web standards organisation that also develops web specifications, guidelines, software and

## A life's work

The road to an invention that truly changed the world

1976

He graduates from the University of Oxford, achieving a first-class degree in physics.

1990

The first web client and server is written by Berners-Lee.

1955

Berners-Lee is born on 8 June in London to parents Conway Berners-Lee and Mary Lee Woods.

1989

While working at CERN, Berners-Lee invents the World Wide Web.

1994

He becomes the director of the World Wide Web Consortium, developing interoperable technologies.



# Weaving the World Wide Web

The concept of the World Wide Web is relatively simple: it works to provide the user with information from a variety of sources in a non-linear fashion, hence a 'web'. The construction, however, is not so simple. Sir Tim Berners-Lee used something called hypertext to achieve this. By allowing text to hold more text and other information within it, users can jump from one place to another. It works in a similar way to how a hyperlink would work on a text document but in a continuous fashion. Combined with the global capacity of the internet, hypertext is placed within browser platforms and held on different servers to enable global connectivity.

## THE BIG IDEA

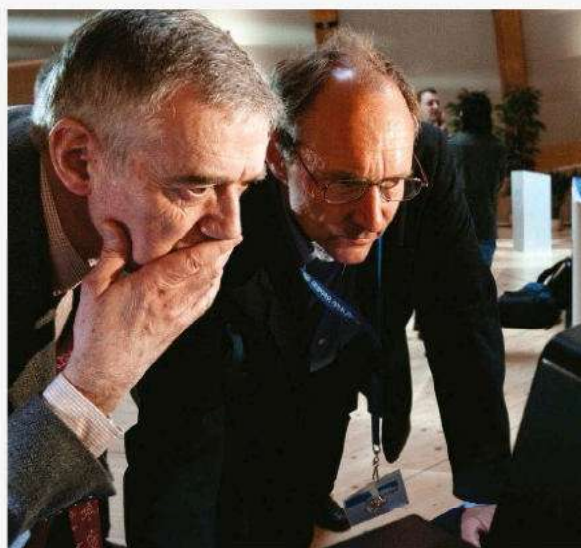


With the use of servers and the internet, hypertext documents can be accessed from across the globe

tools. With the continued success of the iconic 'www.', Berners-Lee founded the World Wide Web Foundation in 2009, an organisation working to deliver digital equality to the world.

Berners-Lee has been honoured with multiple awards over the years, including the prestigious ACM AM Turing Award (referred to as the 'Nobel Prize of computing'). In 1997, he was appointed an Officer of the Order of the British Empire (OBE), then in 2004 he was promoted to Knight Commander (KBE) "for services to the global development of the internet".

Following decades of scientific and economic success, Berners-Lee has now returned to his Oxford University roots. Joining the staff as a Professor of Computer Science, Berners-Lee is inspiring the next generation of digital creators.



Scientist Robert Cailliau (left) worked with Sir Tim Berners-Lee (right) on the World Wide Web project using the NeXT Cube computer



The NeXT Cube was the computer used to create the World Wide Web and was exhibited at the London Science Museum

"This new way to obtain information was something Berners-Lee wanted the entire world to have access to"

## 5 THINGS TO KNOW ABOUT...

### SIR TIM BERNERS-LEE

1

#### He has more than one doctorate

Berners-Lee has been bestowed with honorary degrees and doctorates from institutions around the world, such as the prestigious universities of Harvard and Yale.

2

#### He's in the hall of fame

The Internet Hall of Fame to be exact, launched by the Internet Society in 2012 to celebrate the living history of the internet and its many extraordinary contributors.

3

#### He was in the Olympics

You may have spotted Sir Tim in the opening ceremony of the 2012 Olympic Games in London, sat with the computer he originally used when developing the Web.

4

#### His parents were pioneers too

As mathematicians, his parents Conway Berners-Lee and Mary Lee Woods worked on the world's first commercially built computer, the Ferranti Mark 1.

5

#### The Web wasn't his first creation

Called ENQUIRE, in 1980 Berners-Lee designed a computer system to find and share information.

1999

Publishes his book *Weaving the Web*, which describes the development of the World Wide Web and his role in it.

2009

Berners-Lee is elected the foreign associate of the National Academy of Science.

2016

Berners-Lee wins the ACM AM Turing Award for the invention of the World Wide Web.

2004

Knighted by Queen Elizabeth II for services to the global development of the internet.

2013

Awarded the Queen Elizabeth Prize for Engineering for "groundbreaking innovation in engineering that has been of global benefit to humanity."





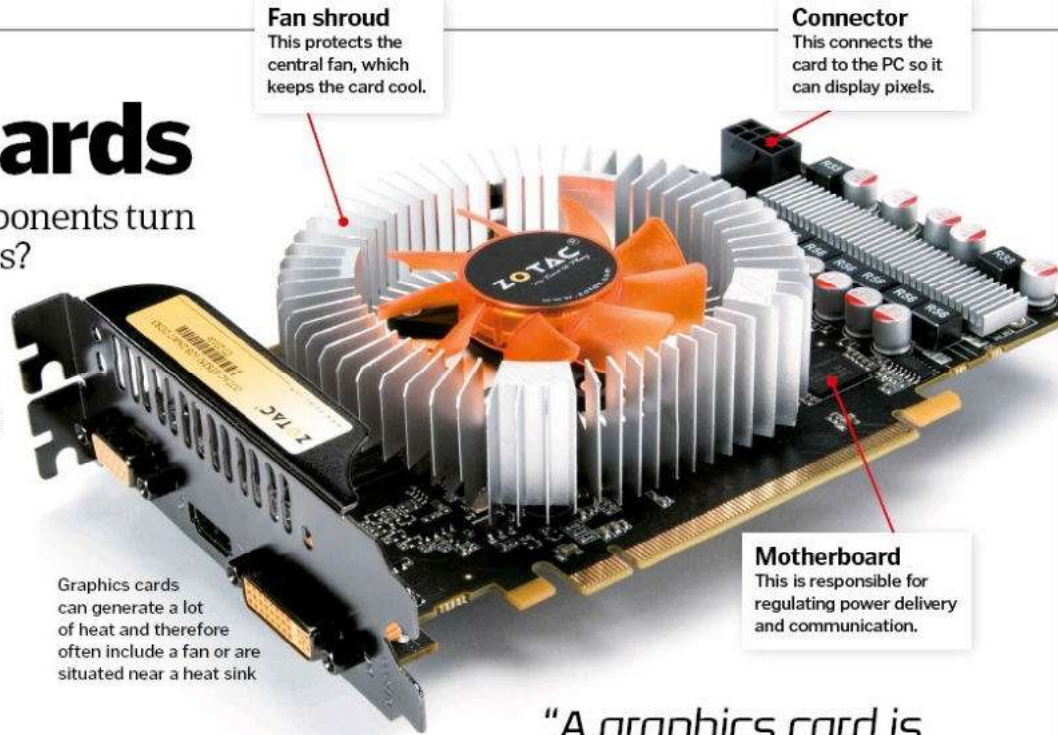
# Graphics cards

How do these computer components turn binary data into pixel pictures?

**C**omputer screens produce images made up of millions of pixels — tiny dots that can each be programmed to display one of millions of possible colours. In order to know which colour each pixel is supposed to present at any given time, a graphics card is needed to effectively translate the computer's binary data into instructions for all of the screen's pixels.

To achieve this, graphics cards comprise four main components: a motherboard, a processor, memory and a connection to the screen. The motherboard allows the components on the card to communicate with each other, as well as enabling them to receive power from the device's battery or mains connection. The processor, also called a graphics processing unit (GPU), is responsible for deciding what each pixel on the screen should be doing. The GPU performs lots of complex calculations in order to do this to ensure graphics are rendered

Graphics cards can generate a lot of heat and therefore often include a fan or are situated near a heat sink



**Fan shroud**  
This protects the central fan, which keeps the card cool.

**Connector**  
This connects the card to the PC so it can display pixels.

**Motherboard**  
This is responsible for regulating power delivery and communication.

accurately and smoothly. The memory temporarily holds the information generated by the processor before it is transmitted to the monitor to produce the image you see on screen.

*"A graphics card is needed to translate binary data into instructions"*

# IP addresses

Understanding the codes that identify our online devices

**I**nternet Protocol (IP) addresses are unique codes used to identify devices on a network. Similar to the way we would use phone numbers to contact specific people, IP addresses are used to send data between internet-connected machines. There are two types of IP address used online: every device connected to the internet uses IP version 4 (IPv4), and some also use the newer IP version 6 (IPv6).

IPv4 addresses are expressed as four numbers separated by dots. For example; 123.45.67.89. This figure is a decimal representation of an eight-digit binary number. Decimal is our standard (base-10) numerical system, whereas binary is the base-2 numerical system that computers use. There are around 4.3 billion possible unique IPv4 addresses, so as the number of internet-connected devices grew, IPv6 was introduced to accommodate increased demand.

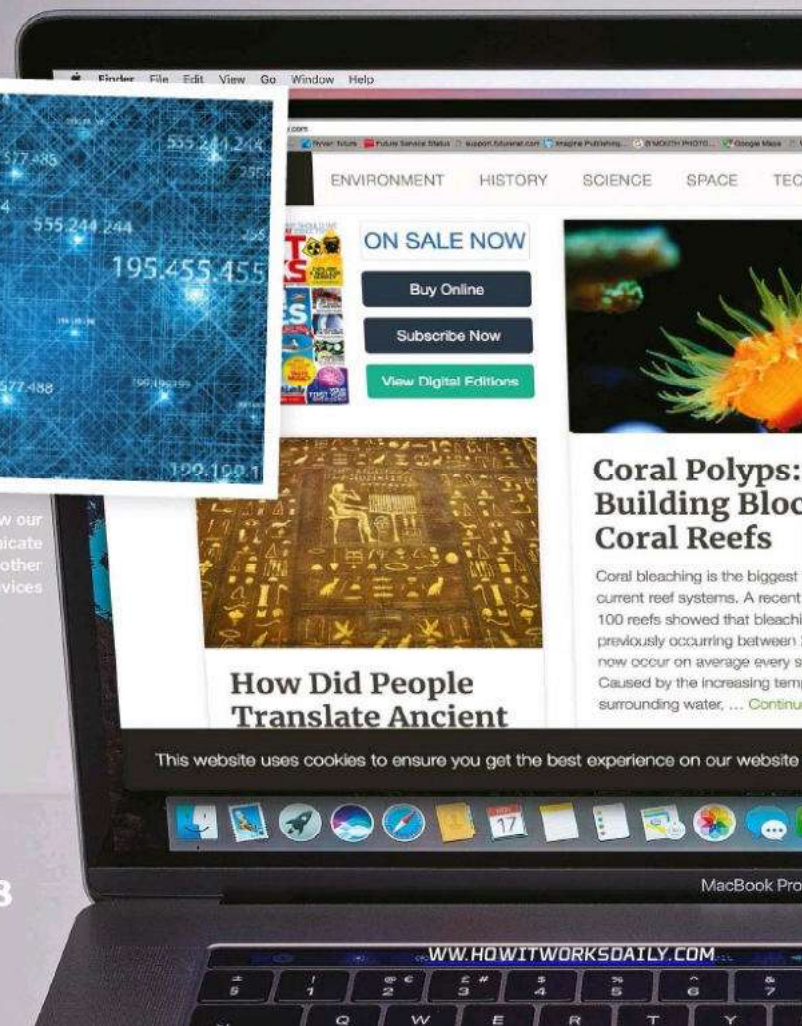
IPv6 addresses are expressed as eight groups of hexadecimal numbers separated by colons, as shown in the example figure below. In this system, there are a possible 340 trillion trillion trillion unique addresses, providing plenty more room for internet growth in the foreseeable future.



IP addresses allow our gadgets to communicate with websites and other internet-connected devices

IPv6 addresses like the example below use hexadecimal, a base-16 system that represents binary data using the numbers 0-9 and the letters A-F

**2001:0db8:0123:4567:89ab:cdef:1234:5678**



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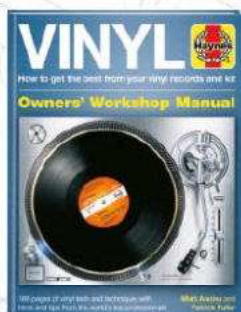
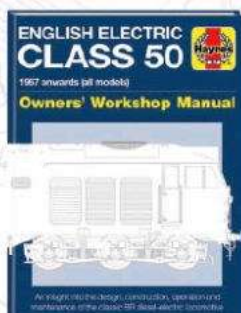
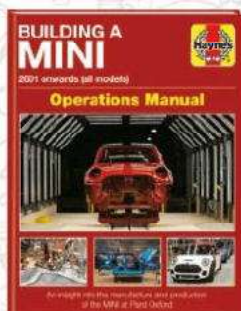
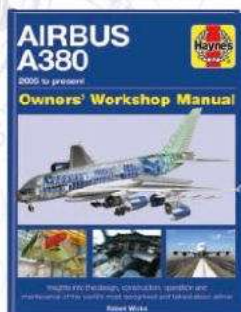
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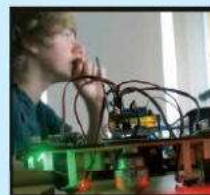
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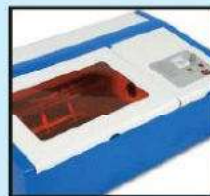
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# How does scaffolding work?

These everyday structures are vital in the field of construction

**Y**ou might notice them being built around an old building on your street almost overnight, but scaffolding can also be used to support structures such as half-pipes, ski ramps and concert stages. Scaffolding is even used to maintain large boats and iconic landmarks such as London's Elizabeth Tower.

The teams of scaffolders need a strong head for heights and impeccable balance. It's no easy task to lift, move and place thousands of steel tubes, weighing approximately 4.5 kilograms per metre, and there is a lot at stake if things go wrong. Though it can look a little precarious to see construction workers on top of dizzyingly tall skyscrapers, feel assured that scaffolding is assembled to a very high standard and is regulated by authorities. However, this isn't a new technology we've developed in recent years. The paleolithic cave paintings at Lascaux in southwest France are accompanied with markings that suggest a scaffold system was built to paint the ceiling around 17,000 years ago.

Today, a scaffolding structure primarily consists of tubes, couplers and boards. Tubes are generally made from steel or aluminium, with a standardised diameter of 48.3 millimetres and are available in different lengths. The couplers are used to hold the tubes together in their familiar grid pattern, of which there are three basic varieties. Finally, the boards allow construction workers to move around on the scaffolding and tend to be made from seasoned wood.



The average heaviest component used in scaffolding weighs 20kg



The Elizabeth Tower is currently covered by scaffolding while renovations take place

## Bamboo scaffolding

Hong Kong's iconic skyline is dotted with skyscrapers, and surrounding many of them is a traditional scaffold structure crafted with bamboo. Instead of steel or aluminium, parts of Asia have utilised this flexible, strong and lightweight wood for centuries. The plant grows in abundance, taking approximately four years to grow to the correct height before being chopped down, dried for two months, and cut into seven-metre tubes to use in construction. It might look precarious to see the wood lashed together with nylon strips, but the design of a grid pattern formed by 75-centimetre squares offers so much stability that skyscrapers up to 70 stories tall can be built using this ancient craft.



Bamboo scaffolding is so lightweight that it can be constructed much faster than metal structures



# Guarding Fort Knox

Discover the impenetrable fortress that safeguards America's gold stores

**T**he US's gold reserves are held in several institutions across the country, but arguably none are more famous than the Fort Knox Bullion Depository near Louisville, Kentucky. Considered to be one of the world's most secure vaults, Fort Knox hosts a significant proportion of the nation's gold in the form of bars and coins (known as bullion).

Construction of the facility began in 1935 and was completed one year – plus over 450 cubic

metres of granite, 3,200 cubic metres of concrete, 750 tons of reinforced steel and 670 tons of structural steel – later. Upon its completion, the Depository was placed under the jurisdiction of the US Mint, and the first shipments of gold arrived in 1937. This precious metal cargo had to be shipped by rail through the US Postal Service as it was too heavy to fly, and the Postal Service were the only couriers able to accept liability if any of the gold went missing.

Since then, the vault's gold reserves have grown considerably, so protecting the facility is paramount. The Fort Knox Depository is reportedly equipped with an array of advanced security systems, some of which are outlined below. Understandably, many of the site's security systems and protocols are classified. In the words of the US Mint, "perhaps the most advanced security system the Depository has to offer is its secrecy".



The facility is protected by officers of the US Mint Police, which is one of the nation's oldest federal law enforcement agencies

## Protecting the vault

What measures are reportedly in place to keep Fort Knox secure?

### Electric fence

The second barrier protecting the installation is a 3m-tall electric fence.

### Final barrier

An additional electric fence surrounds the main facility, with entry points for patrolling guards.



### Natural barriers and backup

The Appalachian Mountains to the east provide a natural barrier against potential attacks. If additional military protection is needed, the many soldiers, tanks, attack helicopters and artillery of the Fort Knox military base are close by.

### Walls and foundations

The granite walls of the facility are around 1.2m thick, and the entire building is built on a cement and granite foundation to protect against any intruders attempting to dig their way in.

### Surveillance and sentinels

Every part of the facility is covered by surveillance systems, and guards are positioned in several sentinel stations around the building.

### Blast-proof doors

The main door to the facility weighs over 20tn and is constructed of blast-proof materials.

### The vault

No member of the Fort Knox staff can enter the vault on their own. Several employees must enter separate access codes, which change each day.

### Perimeter fence

Enclosing the site is a wire fence equipped with motion sensors. Fort Knox sits within the perimeter, surrounded by a large open area to improve surveillance.

Right: during a tour for members of Congress in 1974, then-director of the Mint, Mary Brooks, stands with the stored gold bars in the vault

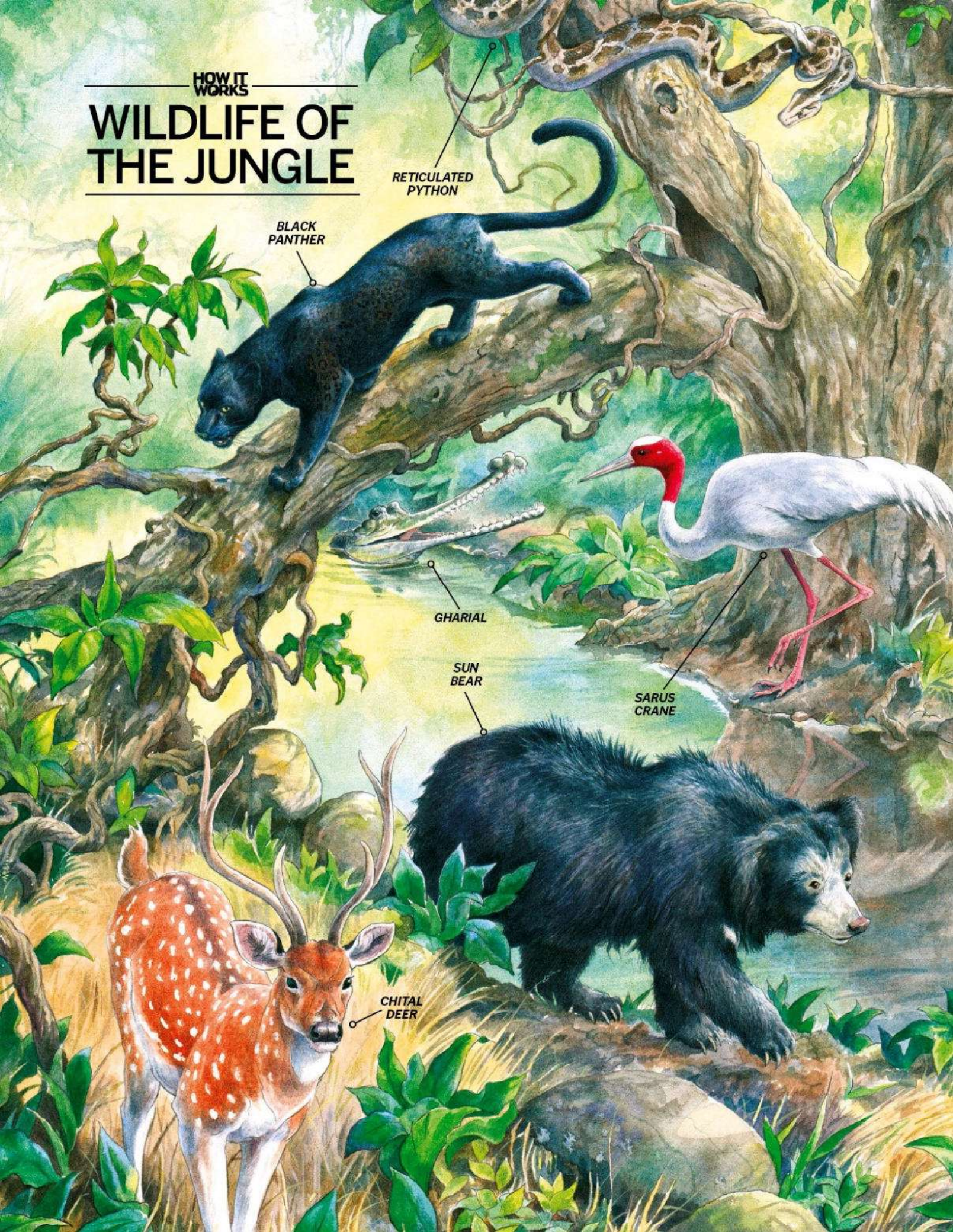


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HOW IT  
WORKS

# WILDLIFE OF THE JUNGLE



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PYTHON

BLACK  
PANTHER

GHARIAL

SUN  
BEAR

SARUS  
CRANE

CHITAL  
DEER





SUMATRAN  
ELEPHANT

LAR  
GIBBON

SUMATRAN  
TIGER

PARADISE  
FLYCATCHER

SMOOTH-COATED  
OTTER







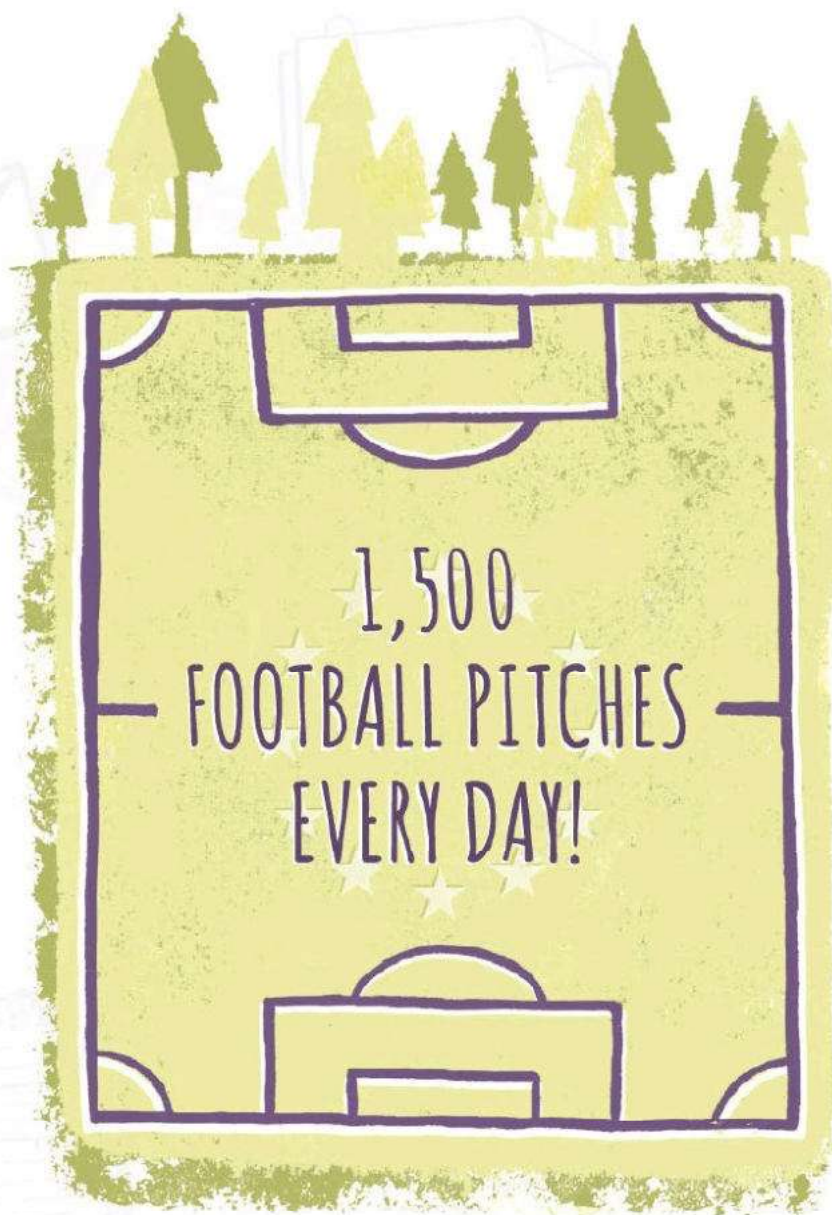
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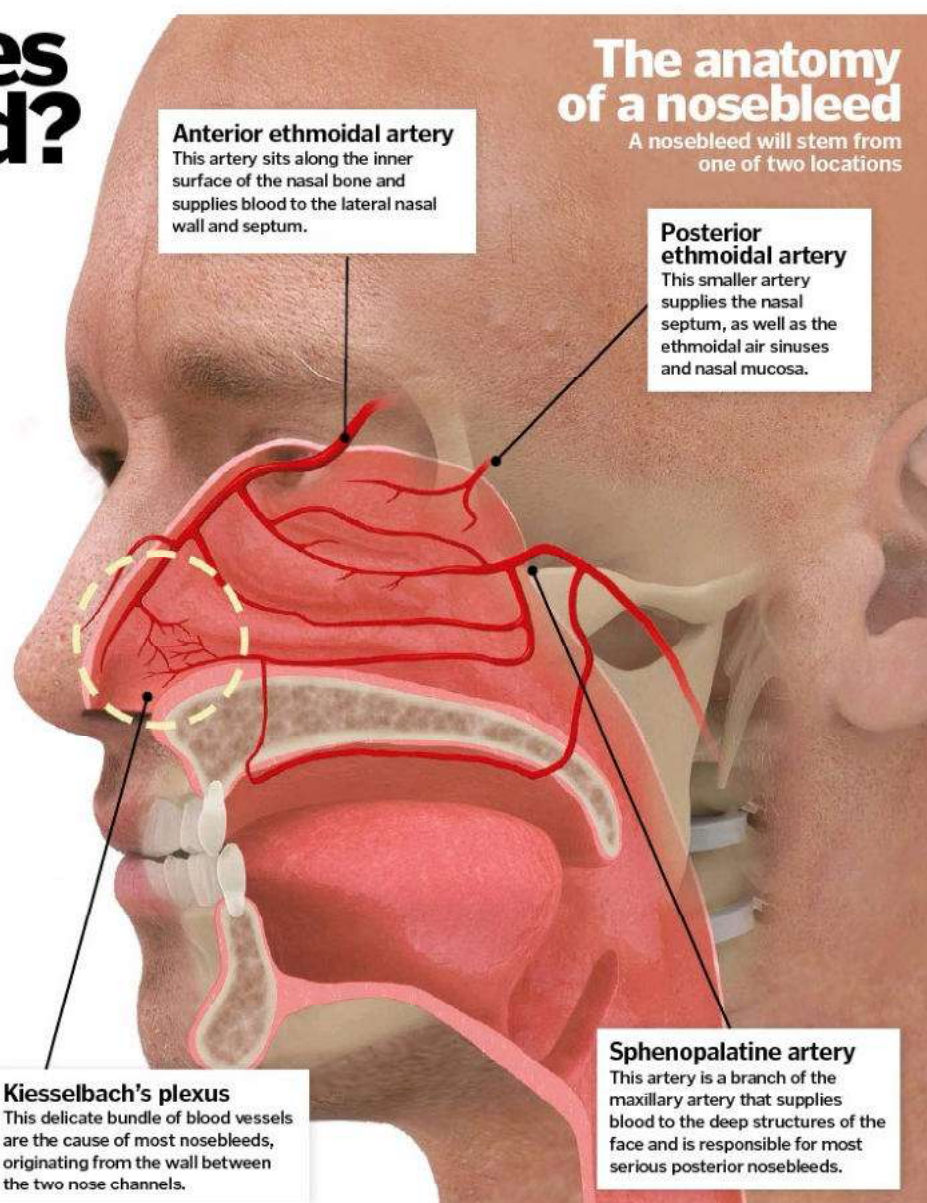
# What causes a nosebleed?

How are the delicate blood vessels in your nose responsible for these unpleasant incidents?

**M**ost of us are familiar with the unpleasant sensation of a nosebleed. They are common because there are so many blood vessels in your nose, and it doesn't take a lot of trauma for them to burst. They can start from one of two places – inside your nostrils (anterior) or at the back of your nose (posterior). Anterior nosebleeds can be caused by a minor injury to the nose, high altitude or allergies. However, posterior nosebleeds start from ruptured arteries supplying blood to the space between the roof of your mouth and your brain. These more serious bleeds are less common and are caused by head injuries or a broken nose, among others.



Nosebleeds are caused by the rupture of tiny, delicate blood vessels



## The anatomy of a nosebleed

A nosebleed will stem from one of two locations

### Anterior ethmoidal artery

This artery sits along the inner surface of the nasal bone and supplies blood to the lateral nasal wall and septum.

### Posterior ethmoidal artery

This smaller artery supplies the nasal septum, as well as the ethmoidal air sinuses and nasal mucosa.

### Kiesselbach's plexus

This delicate bundle of blood vessels are the cause of most nosebleeds, originating from the wall between the two nose channels.

### Sphenopalatine artery

This artery is a branch of the maxillary artery that supplies blood to the deep structures of the face and is responsible for most serious posterior nosebleeds.

# Activated carbon

What chemical properties make this fine black powder so useful?

**A**ctivated carbon, also known as activated charcoal, is a form of carbon that has been processed to create an extremely porous structure. It is made by heating carbon-rich materials to an extremely high temperature until pure carbon is formed and is then generally activated in a steam atmosphere to incorporate air bubbles within it to increase its surface area. This versatile, fine black powder gets its amazing abilities from the tiny holes within it that can trap chemicals, making it useful in a wide range of different industries.

Activated carbon can be utilised in a variety of filtration and distillation methods due to its adsorption properties, including water and air purification and sewage treatment. One of the most vital industries that use this type of charcoal is emergency medicine, where it's used to treat poisoning and overdoses, by binding with toxins to prevent them from being absorbed into the body. Recently, there has been a trend of using charcoal to whiten teeth, but there is no scientific evidence to prove that this method actually works.

Just 1g of activated charcoal can have a surface area of 500-1,500m<sup>2</sup>





# The scale of cells

Find out why the dimensions of your body's cellular components are truly out of this world

**T**he average adult human body is around 1.6–1.8 metres in height and packed with some 30 trillion cells. But if you were to take some of your body's individual tissues and cells and place them in a straight line, they would stretch much further. When you consider the dimensions of DNA, these values become truly astronomical.

Most cells in the body contain 23 chromosomes, each of which consists of tightly wound coils of DNA. If you were able to unwind all the DNA in a cell, it would stretch to a cumulative length of about two metres. With an estimated 37.2 trillion cells in the average human body, all this DNA stacked end to end would create a strand 74.7 billion kilometres long, enough to reach from Earth to the Sun and back almost 250 times!

**DNA**  
If unravelled, the DNA in the average human body would stretch for a cumulative distance of over 74 billion kilometres.

Your DNA could stretch to the Sun and back nearly 250 times!



## Myelinated neurons

With billions of neurons in the brain alone, it's difficult to estimate the total length of nerve fibres in the human body. A Danish study in 2003 investigated the brain's white matter (consisting of myelinated nerve fibres) and found the average 20-year-old has between 149,000 and 176,000 kilometres worth. This number inevitably rises if the entire brain and the rest of the body are considered.



## Blood vessels

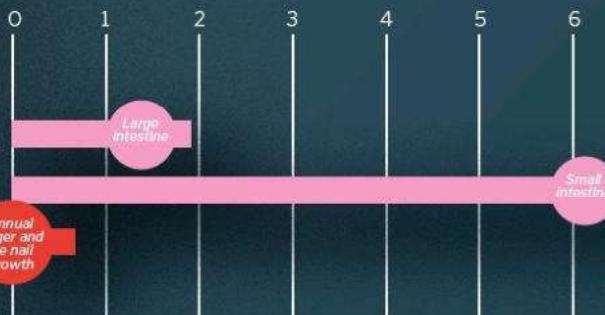
Your body contains a vast network of arteries, veins and capillaries to transport blood around the body. The longest vessel is the great saphenous vein, which runs from the thigh to the top of the foot, while the smallest vessels are tiny capillaries. Some capillaries are less than five micrometres (0.005 millimetres) long — less than one-third the width of a human hair.



## Red blood cells

It is estimated that there are around 20–30 trillion red blood cells in the average adult, more than all the other cells of the body combined. These cells are among the smallest in the body, approximately six to eight micrometres (0.006–0.008 millimetres). Their tiny size and biconcave disc shape increase their surface-to-volume ratio, enabling them to carry more oxygen.

METRES



## Digestive tract

The small and large intestines are named by their widths rather than their lengths. The small intestine is very long but relatively narrow, while the large intestine is shorter but wider.

*"If unwound, the DNA in a cell would stretch to a cumulative length of about two metres"*

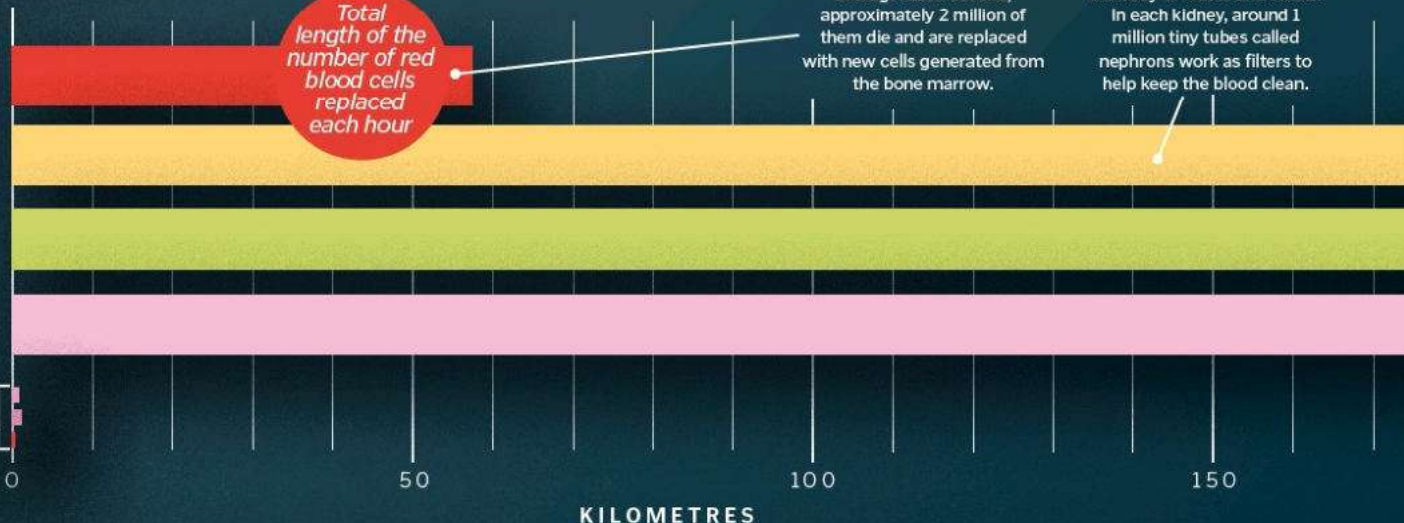
## Rapid replacement

Red blood cells are continually replaced and have a lifespan of between 100–120 days on average. Each second, approximately 2 million of them die and are replaced with new cells generated from the bone marrow.

## Kidney filter tubes

Your blood is filtered through your kidneys around 40 times each day to help rid the body of waste and toxins. In each kidney, around 1 million tiny tubes called nephrons work as filters to help keep the blood clean.

Total length of the number of red blood cells replaced each hour



KILOMETRES



## Bigger than your body

How your cells, vessels and DNA stack up

Opposing electrical charges between histone proteins and DNA molecules enable tight bonds to form

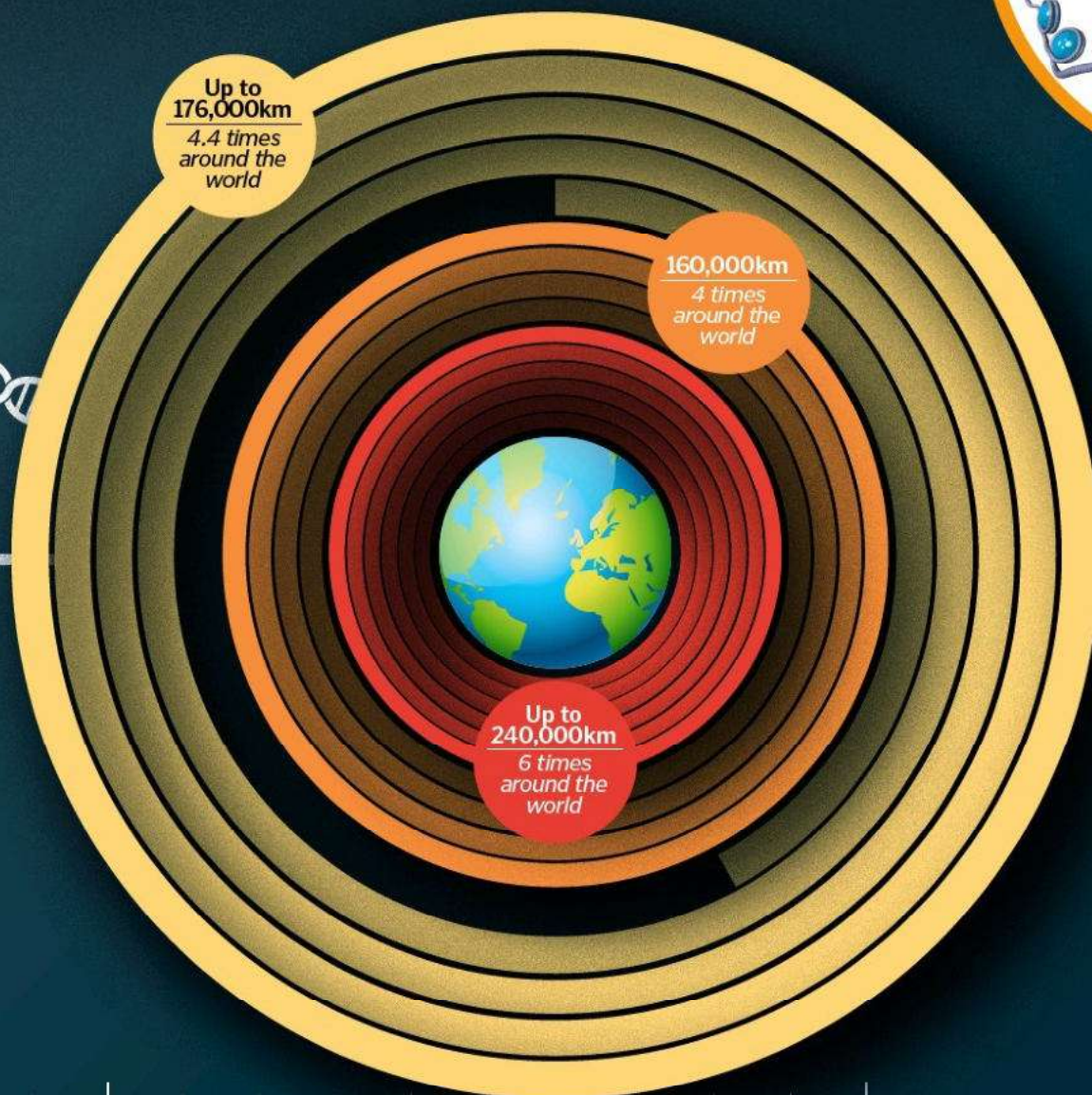


## Space-saving DNA

How is so much DNA packed into the space of a cell nucleus that's only around two to ten microns (0.002-0.01 millimetres) wide?

Each double helix strand is wrapped around proteins called histones to form structures called nucleosomes, which under the microscope have the appearance of beads on a string. These nucleosomes coil up, further compressing the DNA molecule into compact fibres. The fibres are then tightly folded to produce the 250-nanometre-wide fibres that make up chromosomes.

This arrangement is adjustable, so portions of DNA strands can effectively be opened up when the molecule needs to be 'read' during transcription or replication. Since these structural changes are reversible, the DNA reverts to its compact form when these processes are complete.



Filter tubes in the kidneys

How far the fastest nerve impulses could travel in an hour

### Superfast signals

Different nerves transmit impulses at different speeds. The fastest are myelinated neurons, which have axons surrounded by a fatty substance that act like insulation around electric cables. These types of nerves are usually responsible for sensory detection, such as sight.

Skin cells

### Largest organ

Your skin is your largest organ, covering an area of around 1.6-1.8 square metres in the average adult. Stacked end to end these small cells would cover a surprising distance.

200

250

300

350



# Tightrope forces

Why these death-defying feats rely on a keen understanding of physics and physiology

**T**o mesmerised audiences below, tightrope walkers seem capable of performing impossible stunts. Even on the ground, without the distraction of being at a dizzying height, attempting to balance upon — let alone move across — such a thin rope seems incredibly difficult, but in fact it's all just a matter of understanding the forces involved in balance and rotation.

The body's posture affects its centre of gravity: the point at which its mass is balanced in every direction. A lower centre of gravity improves

stability; think of how a short, wide glass is harder to knock over than a tall, thin one. One way to lower this centre is to lean forward, but tilting the head interferes with the body's vestibular system, the part of the inner ear responsible for balance. Instead, the best tactic is to keep the back and head as straight as possible while keeping the knees bent to lower the hips slightly.

Another factor walkers must consider is the rope's tendency to rotate underfoot in response to their own movements. By holding out their

arms, or holding a long balance pole, they can spread out the horizontal component of their mass. This increases their rotational inertia, which helps to resist the motion of the twisting rope and thereby improves stability.

Understanding the physics and using these principles to your advantage is one thing, but performing them at height is another thing entirely! Developing the confidence — and a head for heights — to perform wire walks between skyscrapers or across waterfalls takes many years of intensive training.

The rope's tautness is another factor to take into account; more slack means the rope is more likely to wobble as you walk



## Balancing act

Discover the science behind a successful tightrope walk

### Centre of gravity

The point where the mass of a walker's body balances out is usually near their waist. Bending the knees helps to lower this slightly.

### Tension

How tense the rope is will affect how the walker can move across it. The more slack the rope, the more it will move with each step.

### Vestibular system

Keeping good posture, with the head up and looking straight ahead, is important for the walker's balance.

### Rotational inertia

Long balance poles increase the walker's rotational inertia — a measure of how difficult it is to change an object's rotational velocity around an axis. This enables the walker to resist the turning of the rope more easily.

### Friction

Tightrope walkers' footwear is typically leather or suede to increase friction between the shoes and the rope, improving grip. Flexible, thin-soled shoes also help walkers bend their feet around the rope.

### Head for heights

Beyond the laws of physics, psychologically it takes focus, determination and years of practice for high-wire walkers to overcome the natural fear of great heights.

### Safety line

A safety harness — loose enough to avoid impairing movement — can be used to fasten the walker and their pole to the wire in case of disaster. Some daredevil tightrope walkers don't use any safety equipment at all!





# Crohn's disease

How does this condition damage the digestive system?

**C**rohn's is an inflammatory bowel disease that causes tissue destruction along the gastrointestinal tract, anywhere from the mouth to the anus. This leads to a variety of nasty symptoms, such as abdominal pain, fatigue and unexplained weight loss.

It's referred to as an immune-related disorder, though it's not strictly autoimmune because it

isn't the body's own cells triggering a war against itself. Instead, it is thought that a combination of genetics, environmental factors and bacteria in the gut cause the abnormal immune response that attacks healthy cells of the gastrointestinal tract. Currently there is no cure for this disease, though diet and medication can help reduce flare-ups.

## The leading theories about Crohn's

Although scientists don't know exactly what causes Crohn's, there is a growing body of research suggesting it might be caused by one of three mechanisms

### Autoimmune theory

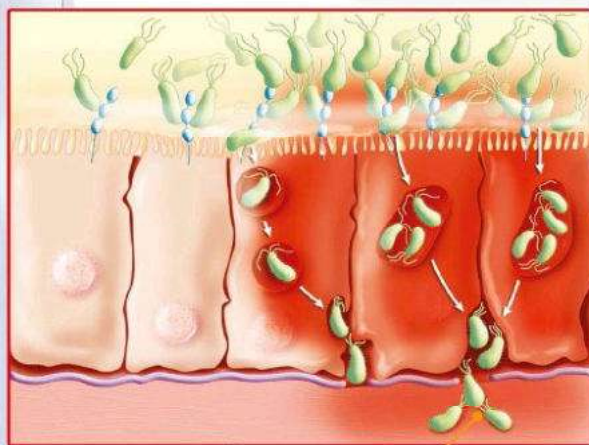
This hypothesis proposes that a specific infectious agent does not exist, but impairment of the intestinal lining and the influence of gut bacteria can trigger an autoimmune response.

### Immunodeficiency theory

This idea suggests that a defective process within the body's innate immunity leads to compensatory responses, and that therapies should aim to boost immunity rather than suppress it.

### Mycobacterial theory

This theory suggests that *Mycobacterium avium paratuberculosis* is a cause of Crohn's. This pathogenic bacteria interferes with the immune signalling pathways as part of a survival strategy.



### Pathogens

An impaired immune system makes it easier for pathogenic bacteria to colonise the intestinal walls and cause harm.

### Chronic condition

After its onset, Crohn's is a life-long disease. Sufferers typically experience symptoms in phases, with flare-ups interspersed with periods of remission.

### Inflammation

The areas most commonly affected by Crohn's are the large intestine or the end of the small intestine.

# Breathprints

Could your breath be as unique as your fingerprint?

**W**e all know that no two fingerprints are identical, but new research is suggesting that your breath may be as unique as the patterns on the tips of your fingers.

When you breathe out, it's not just CO<sub>2</sub> you're releasing into the atmosphere; there are also leftover metabolites from all the processes that are required to keeping your body alive. Renato Zenobi at the Swiss Federal Institute of Technology in Zurich and his colleagues discovered breathprints by analysing the exhalations of 11 healthy individuals and found they remained stable over each day and over the course of the investigation (nine days). This means that although we already use breathalysers to test alcohol content, we could also potentially use them to detect a lot more. Your individual breathprint has a specific chemical pattern which is unique to you, so changes in it could indicate disease. Using a mass spectrometer (a device that separates molecules by mass) it is possible to map a patient's unique breathprint, track changes and detect patterns that suggest there may be an underlying condition.

The next stages of research will attempt to determine aspects of breathprints that are indicative of disease. This faster, cheaper and less invasive diagnostic method could replace blood tests, providing the molecules of interest are volatile and small enough to be passed from the blood into the alveoli of our lungs.



Your breath contains metabolites that could be used to diagnose disease

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Folding bikes use a series of hinges and clips to create a compact, easy-to-carry package

## Folding bikes

The contorting bicycles that make it easier to get from A to B

**T**rying to get on a packed train with a bike can often result in competing for space.

Folding bikes, however, have made boarding a bit more bearable. As with normal bikes, these compactable cycles come in all shapes and sizes. Some split horizontally, tucking the wheel underneath, while others turn the handlebars on their head.

The trick is in the hinges and extending stems that support the frame. Different bikes use different hinge technology. For example, manufacturer DAHON employs an easy-to-use ViseGrip hinge, and a LockJaw hinge cuts the main frame in two as it swings at the centre.

The Rolls-Royce of folding bikes, the Brompton, can fold down in under 20 seconds, making it a perfect city bike. Brompton models have been paving the way since 1975. Folding to just 58.5 centimetres tall, 56.5 centimetres long and 27 centimetres wide, the Brompton retains its structural integrity in a compact package. In

order to avoid getting caught up with the folding frame, chains and gears remain in the centre of the bike. Folding both horizontally and vertically in four steps, the Brompton appears to completely collapse under its creative and innovative design.



Thanks to their space-saving versatility, folding bikes have become popular with urban commuters

## Lesser-known distances

Before the more modern metre, people used a range of other measurements

### FURLONG

This is an old English unit created to measure a standard length of ploughed furrow that could be cultivated by an ox without rest. The furlong is still used today to measure the distances run by racehorses.

**1 FURLONG = 201.168 METRES**

### ROD

Also known as a 'perch' or 'pole', the rod derives from the old English word 'rodd'. Originally used for measuring out agricultural distances, it is still used today in horticulture, particularly to measure the size of allotments.

**1 ROD = 5.029 METRES**

### LEAGUE

The league has been used in many regions of the world, including ancient Rome, France and Spain. Introduced to England by the Normans, it was suggested to be the distance that could be walked in one hour.

**1 LEAGUE = APPROX 4.82KM**

### NAUTICAL MILE

This measurement is used by seafarers. Imagine if the Earth was cut in half at the equator, revealing a 360-degree circle. Each degree can be split into 60 'minutes', or arcs. Travelling on water for one minute of latitude covers a distance of one nautical mile.

**1 NAUTICAL MILE = 1,852 METRES**

### KLICK

A klick isn't actually an unusual measurement – it's just military slang for kilometre. It is said that the term derives from a form of measurement conducted during military treks, in which designated soldiers would count the paces of the troops, moving the gas regulator on their rifles back by one mark every 100 metres. After ten marks they would reset the regulator – indicating 1,000 metres – which would make a 'click' sound.

**1 KLICK = 1 KILOMETRE**





# The Ford Mustang's 2018 facelift

Leaner and meaner, the new Ford Mustang marks another milestone in its track history of more than 50 years of continuous production

**T**he Ford Mustang could be the most iconic sports car in the world. The history of this all-American classic vehicle started with the characteristic prototype – the 1962 Ford Mustang I. This original two-seater, with its sleek design and mid-sized engine, while sharing few design similarities with its descendants, would give rise to not only the first generation of Mustangs but eventually an entire new class of car known as the 'pony car' – distinctive, sporty coupes with long hoods and short rear decks.

On the first day of the Ford Mustang II's release in 1964 around 22,000 Mustangs were sold, and over 1 million were on the road within the first 18 months of their production. From these humble beginnings came a further five generations of the cars, the latest of which was unveiled in December 2013.

## What's new

Discover the design, performance and technologies of the latest model of this automotive icon

### Engine

The standard 2018 Mustang features a 2.3-litre EcoBoost four-cylinder engine, offering 290 horsepower. The GT model includes a reworked 5.0-litre V8 engine, providing 450 horsepower – more than any previous Mustang GT.

### Instrument cluster

This fully customisable, all-digital LCD instrument cluster offers a variety of screen layouts and colour options for drivers to personalise.

This year Ford announcement that this historic car will be seeing yet another facelift – one that will make it leaner and meaner than ever with the interior being inspired by an airplane cockpit; designed to ensure an exhilarating ride. Featuring a reprofiled bonnet and tweaks to the engine and suspension, the latest Ford Mustang will be available in two models: one with a 2.3-litre EcoBoost engine and the other with a powerful V8 engine (additional to the EcoBoost engine). Additionally, two style options are offered: a fastback or convertible, with four engine and transmission choices.

2018 will see the introduction of this new iconic car, a vehicle brimming with the characteristic charm of its predecessors.



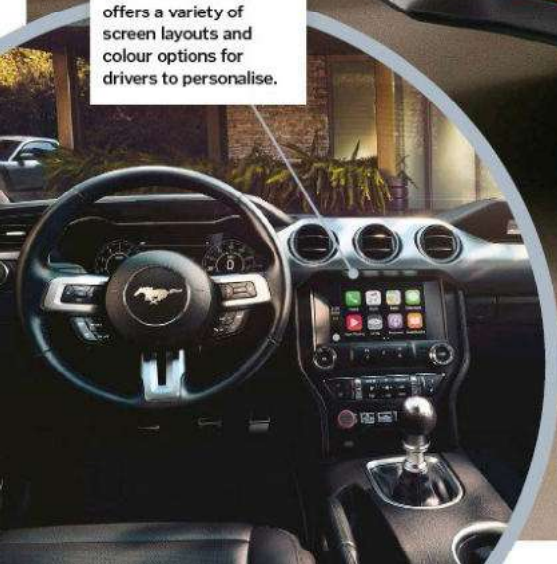
The recommended on-the-road price starts from around £35,995 (approx \$49,000)



### Sleeker design

The facelift is leaner and meaner but keeps the characteristic charm of a Mustang.

"The historic car will be seeing yet another facelift – one that will make it leaner and meaner than ever"





## Mustang movie stars

The character and charm of the Ford Mustang quickly saw the cars make their way onto the big screen. The Mustang made its debut in *Goldfinger*, the Bond movie that quickly accelerated the car to star status.

Since this first appearance, the classic car has been featured in films and TV shows more than 3,000 times, from *Transformers* to *Fast and Furious*, and driven by stars including Will Smith and Steve McQueen. The vehicle has been so influential in the film industry that Ford honoured the legendary movie *Bullitt* by releasing the Mustang Bullitt on the 40th anniversary of its release.



Actor Tom Cruise drove a Mustang in the 2001 movie *Vanilla Sky*

### Driver-assist technologies

The 2018 model will be the first Mustang to include several autonomous systems, such as emergency braking and lane-assist, which use radar and cameras to recognise and help avoid potential hazards.

## FIVE FANTASTIC FACTS ABOUT THE FORD MUSTANG

### 1 Most expensive

The most valuable Mustang sold at auction was a 1967 Shelby GT500 Super Snake. It sold for \$1.3 million (just under £1 million).

### 2 50 years of production

The Mustang has been produced for more than five decades, never missing a model year.

### 3 Empire State of 'Stang

In October 1965, a 1966 Mustang was sliced into four sections, carried up on an elevator to the top of the Empire State Building, and reassembled for a display. Amazingly, this was all done in just six hours!

### 4 Built for speed

Dan Gurney sped around in the working prototype of the Mustang I at the Grand Prix circuit in New York in 1962 and was only a few seconds off the record-breaking Formula 1 cars of the time.

### 5 Huge fanbase

The Ford Mustang is the most popular car on Facebook, with over 8.5 million likes and 8.3 million followers to date.

### Noise reduction on demand

The all-new Quiet Start function allows drivers to reduce the volume of the engine's roar at scheduled times, such as early mornings or late evenings to avoid disturbing neighbours.

### Handling

The upgraded chassis offers an improved ride and better handling, including new shock absorbers for better control.

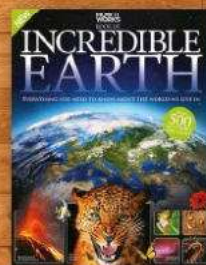
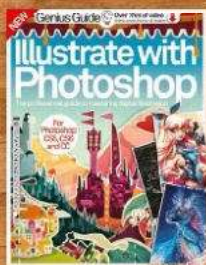
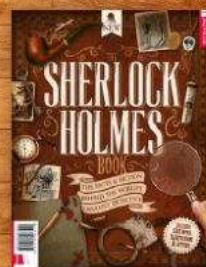
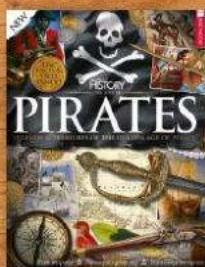
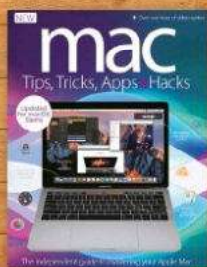
Drivers will be able to alter the gauge layout displayed on the LCD instrument cluster

### Smooth suspension

The optional MagneRide® adaptive technology uses sensors to adjust suspension based on multiple factors including speed, steering angle, brake pressure, and acceleration.

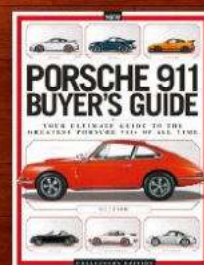
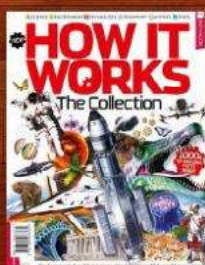
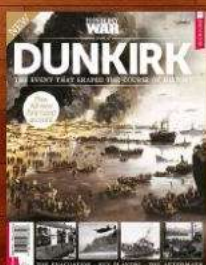
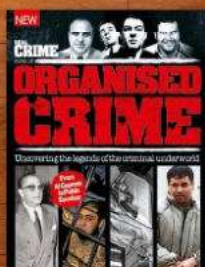
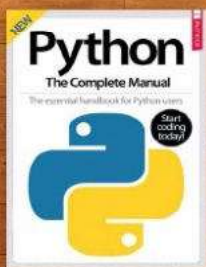
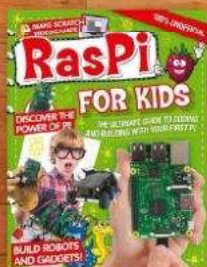






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# Venetian gondolas

The creative masterpieces that cruise the canals of Venice

Narrow cobbled streets, vibrant colourful houses and rustic red roof tiles: Venice is known for its character and charm. Built on an archipelago in the Adriatic Sea, the romantic ambiance of the city is steeped in history and tradition from the marble palaces, ornate bridges and Venice's iconic waterway transport: gondolas. These flat-bottomed boats, with a high point at each end, are operated with a rowing oar in a sculling motion. The gondolier stands facing the bow and rows with a forward stroke before executing a compensating backward stroke.

The boats' origins are lost to history, with the first reference to them gliding the canals of Venice appearing in 1094. They didn't resemble

the iconic water vessel we know today and have undergone several changes to truly perfect the art of navigating low-hanging bridges and mud-flats. The 13th-century gondola had 12 oars, and by the 15th century the vessel had shrunk in size and gained a cabin (felze).

Gondolas quickly became a status symbol, with owners adorning their boats in lavish silks and precious metals. In 1562, authorities introduced legislation that required all gondolas to be painted black. Such displays of grandeur were frowned upon by the religious community, so this measure was introduced to prevent unnecessary ostentatious displays of wealth. Gondola artisans were restricted to only including specific decorations, a design tradition

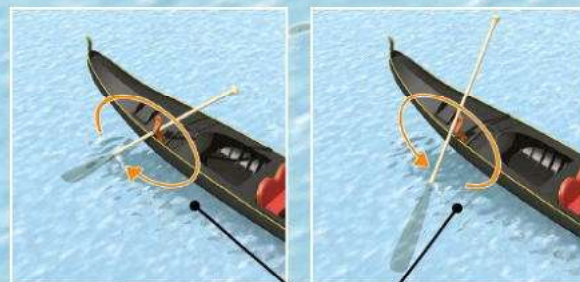


Venetian gondolas are designed perfectly to navigate the city's narrow waterways

that still continues to this day. It is estimated approximately 10,000 gondolas graced the waterways during the 1600s. These were also accompanied by batellas, caorlinas, galleys and other boats. Today, there are only around 400 licensed to work on the canals, and traditionally gondolier licenses and crafting methods were passed down from father to son. To date, there is only one official female gondolier.

## The art of rowing a gondola

These asymmetrical shallow boats are perfectly designed to navigate the complex waterways of Venice



### Forcola

This oarlock is a piece of cured walnut wood attached to the stern of the boat that has been fashioned into a curve with various notches in which to place the oar depending on the type of rowing.

### Risso

One of the few ornamental additions permitted by Venetian authorities.

### Gondolier

The gondolier rows and steers from the starboard side of the stern.

### Remo

The rowing oar propels the boat in a sculling manner and acts as the rudder. The gondolier counteracts the spin of the boat by ending each stroke in the push in the shape of 'J' or 'C'.

## Gondola construction

The gondolas of today adhere to strict construction requirements. They must be 35.6 feet long and 4.6 feet wide (10.85 by 1.4 metres) and weigh approximately 700 kilograms, each custom built to the stature of its new owner. The traditional craft involves the manipulation of 280 handmade pieces. There are eight types of wood: lime, larch, oak, fir, mahogany, walnut, elm and cherry. The boat is built around a wooden template, starting with the bow and stern, before building up the flat bottom and ribs to support the frame. It's a refined process, passed down from generations, taking a total of approximately 500 hours.



Gondoliers are obliged to wear strictly regulated clothing, of either a white sailor's shirt or a striped shirt in red or navy, and a straw boater. In winter, they are permitted to wear a navy woollen reefer jacket

### Ferro

A curving piece of metal sitting at the bow acts as a counterweight to the gondola to keep the boat level.





# Alien asteroid

Astronomers have recently detected our first known interstellar visitor

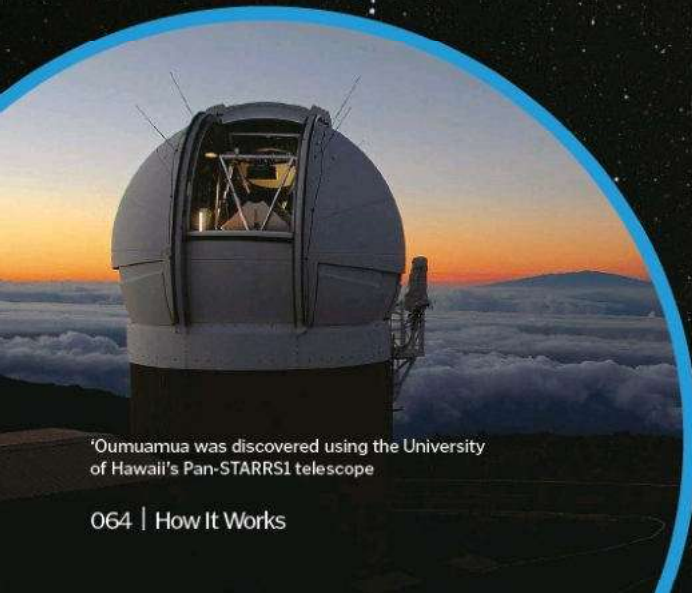
In October 2017, astronomers observed a bizarre body sweeping through our Solar System. Thought to be at least 400 metres long, asteroid 1I/2017 U<sub>1</sub>, otherwise known as 'Oumuamua (Hawaiian for 'a messenger from afar') is the first confirmed object to have travelled to our star system from another. Before its chance encounter with our Sun's gravitational pull, it is thought to have been travelling through interstellar space for millions of years.

While this was not a complete surprise to scientists – who had been anticipating the discovery of an interstellar object for decades – they had been expecting a comet rather than an asteroid. Given that most objects ejected from our Solar System are comets, it had been assumed that a higher ratio of comets to asteroids applied to other systems too, but perhaps this is not the case.

The most obvious oddity of this visitor is its shape. While 'Oumuamua is the length of more than three football pitches, observations suggest it is just 40 metres wide. Such elongation (a ratio of ten-to-one) has never been seen in objects within the Solar System; at most, objects are no more than three-times longer than they are wide.

Structurally, however, the interstellar interloper is more familiar. It seems to be dense – possibly rocky or metallic – and lacks significant amounts of water or ice, just like many asteroids found in our Solar System. As a result of exposure to cosmic rays for millions of years, its surface is slightly red from this irradiation.

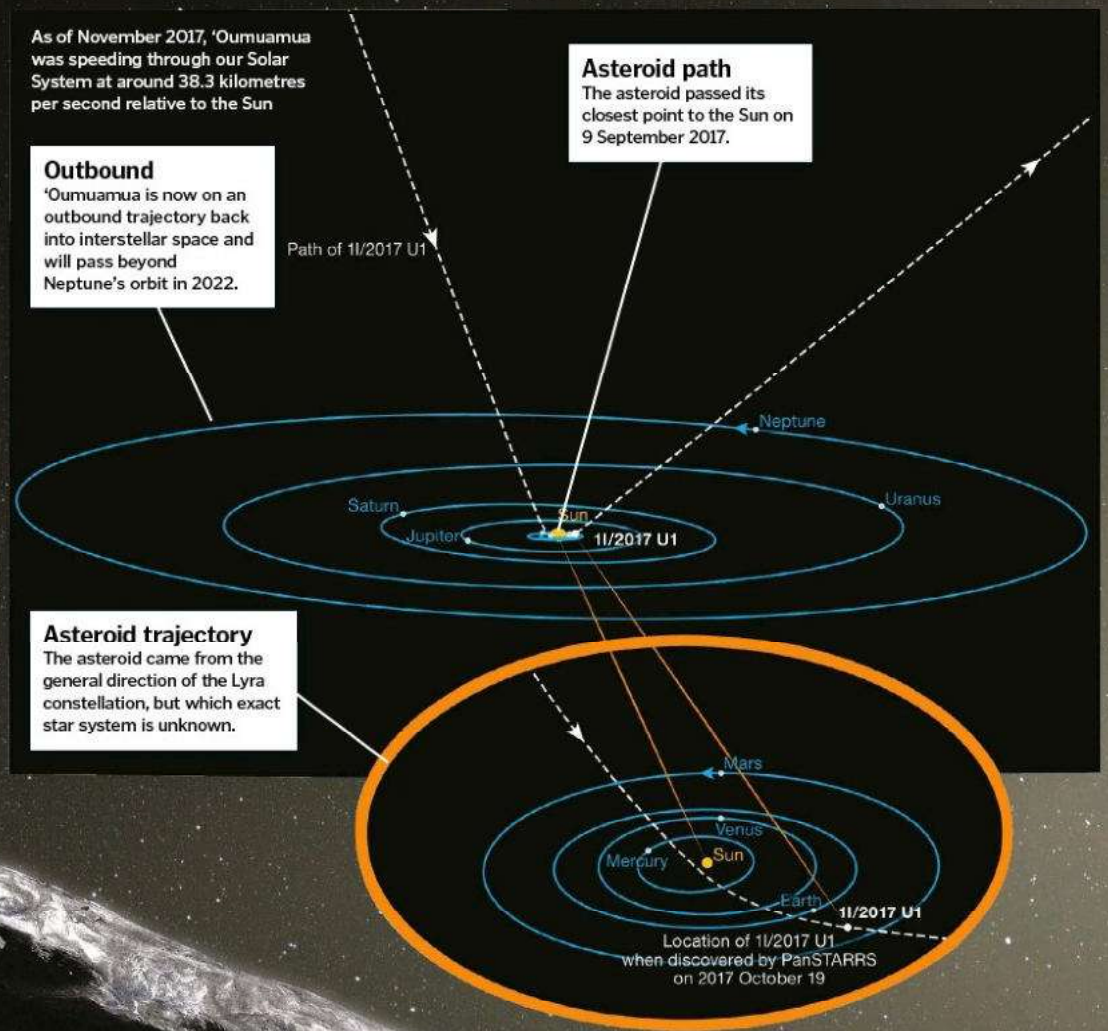
Scientists do not currently understand how 'Oumuamua could have formed or how it has managed to maintain its unusual cigar-like shape. Figuring this out could reveal more about the distant solar system this interstellar traveller came from.



'Oumuamua was discovered using the University of Hawaii's Pan-STARRS1 telescope

*"'Oumuamua is thought to have been travelling through space for millions of years"*









# The evolution of astrometry

Discover how we've been charting the skies for over 2,000 years

**A**strometry is a branch of astronomy concerned with mapping the sky. Records show that it is one of the first sciences and was practised by several early civilisations. Monitoring the movements of stars and planets served a practical purpose for ancient cultures, from tracking time to aiding navigation and timing rituals.

The first astronomers could track visible celestial bodies and record their periodic motions, but it wasn't until the third century BCE that attempts were made to estimate their distances using geometry.

The invention of the telescope in the 17th century led to an astronomy revolution. With an enhanced view of the universe, astronomers could collect more evidence to support the heliocentric model — the idea that the Sun, not the Earth, was at the centre of our Solar System. The telescope enabled much more detailed cataloguing of stars' positions and distances.

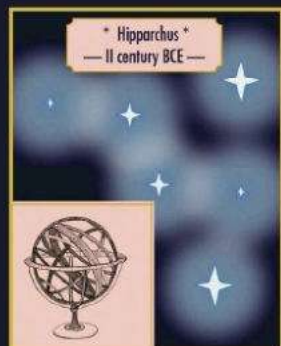
The 19th and 20th centuries saw the development of more advanced telescopes, as well as photography, which improved the accuracy and detail of star charts. But Earth's atmosphere interferes with measurements from

the ground as it makes stars appear to flicker. Since the advent of the space age in the 1950s, we have been able to launch telescopes into orbit, overcoming atmospheric interference to see further into the cosmos than ever before.

ESA's latest mission to chart the skies will rely on the space telescope Gaia, which is currently mapping the position, parallax and annual proper motion of about 1 billion stars. This will provide us with a three-dimensional map of our galaxy in unprecedented detail, as well as a new, definitive stellar catalogue, due to be published in the early 2020s.

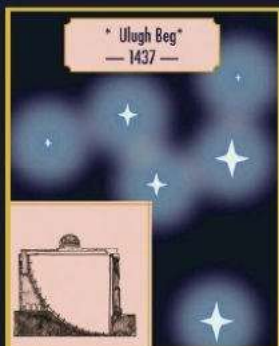
## Astrometry through the ages

How the accuracy of our star maps has improved over centuries of study



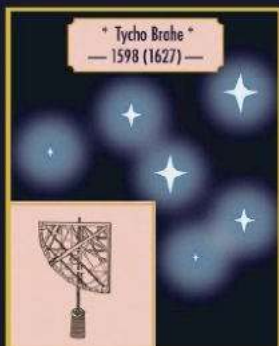
**\* Hipparchus \***  
— II century BCE —

Greek astronomer Hipparchus compiled the oldest known stellar catalogue on record. He was able to map the positions of around 850 stars to an accuracy of one degree using naked-eye observations and astronomical instruments such as astrolabes, gnomons and armillary spheres.



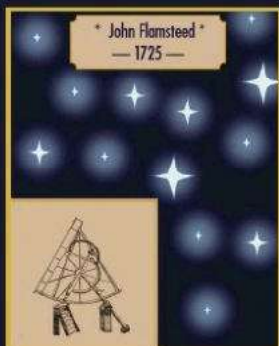
**\* Ulugh Beg \***  
— 1437 —

Timurid ruler and astronomer Ulugh Beg built a 36-metre-radius sextant in Samarkand (a city in modern-day Uzbekistan) to help measure angles in the sky. He created a catalogue of 994 stars, achieving slightly better accuracy than Hipparchus.



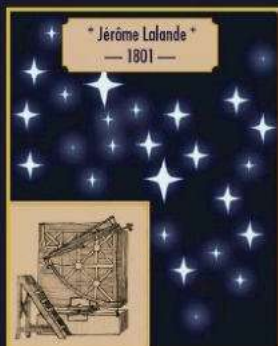
**\* Tycho Brahe \***  
— 1598 (1627) —

Danish astronomer Tycho Brahe's catalogue was completed in 1598 and published in 1627. It contained the positions of around 1,000 stars with an impressive precision of about one arcminute (1/60th of a degree) using large quadrants and sextants.



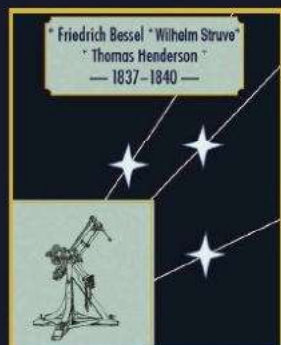
**\* John Flamsteed \***  
— 1725 —

English astronomer John Flamsteed was the first astronomer to publish a stellar catalogue that was compiled with telescope observations. He charted almost 3,000 stars to within an accuracy of ten to 20 arcseconds (one arcsecond = 1/3600th of a degree).



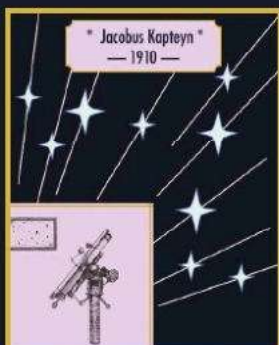
**\* Jérôme Lalande \***  
— 1801 —

French astronomer and writer Jérôme Lalande, who was director of the Paris Observatory, published a huge catalogue of around 50,000 stars. His measurements were precise to around three arcseconds.



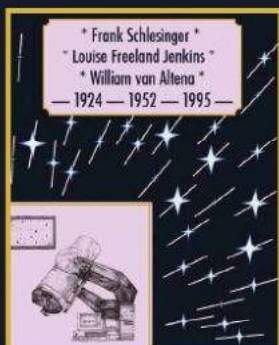
**\* Friedrich Bessel \* Wilhelm Struve \* Thomas Henderson \***  
— 1837–1840 —

In 1838, Friedrich Bessel published the first reliable measurement of parallax: the changes in a star's apparent location due to Earth's changing position in its orbit through the year. In the late 1830s Wilhelm Struve and Thomas Henderson also achieved this, joining Bessel in successfully measuring the distances to stars.



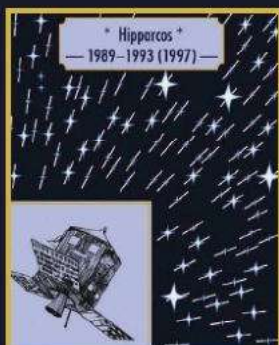
**\* Jacobus Kapteyn \***  
— 1910 —

Dutch astronomer Jacobus Kapteyn was able to measure the parallax of several hundred stars thanks to the development of photography. Since the 1850s, the use of photographic astronomical observations has transformed astrometry and the way we study the skies.



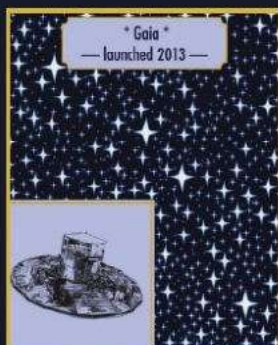
**\* Frank Schlesinger \* Louise Freeland Jenkins \* William van Altena \***  
— 1924 — 1952 — 1995 —

American astronomer Frank Schlesinger used photographic plates to help measure the parallaxes of nearly 2,000 stars, publishing his catalogue in 1924. Louise Freeland Jenkins extended Schlesinger's catalogue to around 6,000 stars in 1952, and William van Altena brought the total to over 8,000 in 1995.



**\* Hipparcos \***  
— 1989–1993 (1997) —

The Hipparcos mission between 1989 and 1993 collected data on the positions, parallax and proper motion of 117,955 stars to an accuracy of 0.001 arcseconds, probing star distances out to over 300 lightyears. The data was published in the *Hipparcos Catalogue* in 1997.



**\* Gaia \***  
— launched 2013 —

Building on the legacy of Hipparcos, Gaia is currently mapping 1 billion stars, which is approximately one per cent of those in our galaxy. It will collect observations on each of its 1 billion targets 70 times. For the brightest stars, Gaia will be able to measure down to an accuracy of 0.00001 arcseconds.



# Mars 2020 vision

A mission to see Mars like it's never been seen before

**M**uch of the Red Planet remains a mystery to scientists. Around half the size of Earth, Mars shows signs of some similarities to our own planet. Both have an atmosphere, experience seasonal change and even have comparable polar ice caps. The biggest difference is the presence of life; well, as far as we understand so far.

Several explorations by NASA's rover technology have examined the possibility of life on Mars. Reaching its five-year mark in August 2017, Curiosity has spent over half a decade taking snapshots of the Red Planet's surface, but now it's time for a new rover to uncover the history of Mars.

Mars 2020 is a rover designed to do just that, as it will be equipped with an advanced set of 'eyes'. A total of 23 cameras make up the visual capability of the rover, which is due to launch in

summer 2020. Divided into engineering, science and entry, descent and landing cameras, Mars 2020 will be able to record as yet unseen sights.

The goal of the mission is to seek signs of preserved life, or biosignatures, in Martian rocks; previous missions have confirmed Mars' habitable conditions. Cameras aptly named SHERLOC and WATSON will use spectrometry to analyse the rock and reveal the story of Mars' geology, as well as look for signs of previous life.

This detective duo are just two of the many cameras on Mars 2020. Another of the rover's impressive instruments is the SuperCam, which can fire its laser at a target beyond the reach of the rover's mechanical arm to analyse its elemental composition. Mars 2020 will also be the first rover designed to collect samples for retrieval, which would be brought back to Earth by a potential future mission.



Above: the 2020 rover's NavCam data can be used to reveal the contours of targets from a distance

## I spy signs of life

Let's take a look at some of the cameras and technology aboard Mars 2020

### NavCams

Two sets of colour navigation cameras will aid the rover's autonomous navigation. Cameras on the rover's mast will see objects as small as a golf ball from 25m away.

### SuperCam

This will fire laser pulses to areas smaller than 1mm from a distance of more than 7m away and in combination with a camera and spectrometers seek organic compounds that could provide evidence of past life on Mars.

### MastCam-Z

This pair of cameras can produce colour images and video and 3D stereo images with a powerful zoom lens.

### HazCams

Six hazard-detection cameras, four at the front and two at the rear of the rover, will evaluate potential hazards such as large rocks and dunes, enabling the rover to navigate around them.

### SHERLOC/WATSON

With the use of spectrometers, a laser and camera lenses, SHERLOC and WATSON can detect organics and minerals in the search for microbial life.

### PIXL

This instrument identifies chemical elements using X-ray fluorescence. The micro-context camera also provides detailed images of the rock and soil textures.

### CacheCam

Positioned inside the rover's underbelly, CacheCam watches over the samples collected from the Martian surface.



# TIME TO STEP OFF THAT TREADMILL

With so many demands from work, home and family, there never seem to be enough hours in the day for you. Why not press pause once in a while, curl up with your favourite magazine and put a little oasis of 'you' in your day.



**PRESS PAUSE**  
ENJOY A MAGAZINE MOMENT

To find out more about Press Pause, visit:  
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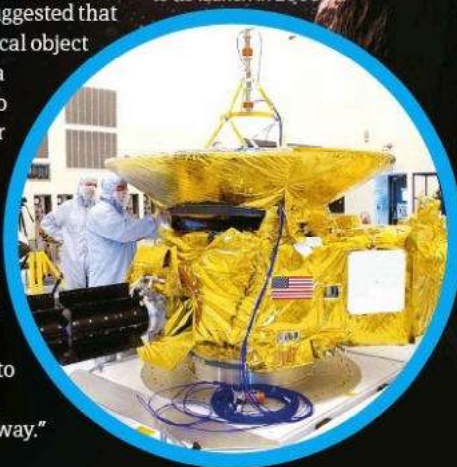
# New Horizons' next target

Could NASA's New Horizons spacecraft be heading toward a binary object?

**N**ew Horizons scientists are preparing for the most distant flyby in the history of space exploration. On 17 July 2017, ground-based telescopes in a remote part of Argentina detected the momentary shadows of the Kuiper Belt object (KBO) 2014 MU69 passing in front of a distant star. MU69's orbit is some 1.6 billion kilometres beyond that of Pluto. This detection has provided vital information about the next destination of the New Horizons spacecraft and gives us a further understanding of the size, shape, orbit and environment surrounding MU69.

These new observations have suggested that the target may not be a lone spherical object as originally thought, but more of a rugby ball shape. Or it could be two objects orbiting very close together or even touching. Marc Buie, the New Horizons co-investigator, is enthusiastic and curious about the new findings. "These exciting and puzzling results have already been key for our mission planning but also add to the mysteries surrounding this target leading into the New Horizons encounter with MU69, now less than [12] months away."

Below: Technicians preparing New Horizons in a clean room prior to its launch in 2006



New Horizons aims to come within 3,500 kilometres of MU69 at its closest approach — three-times closer than the Pluto flyby



The expected trajectory of New Horizons' KBO flyby on 1 January 2019

## Venus' electric winds

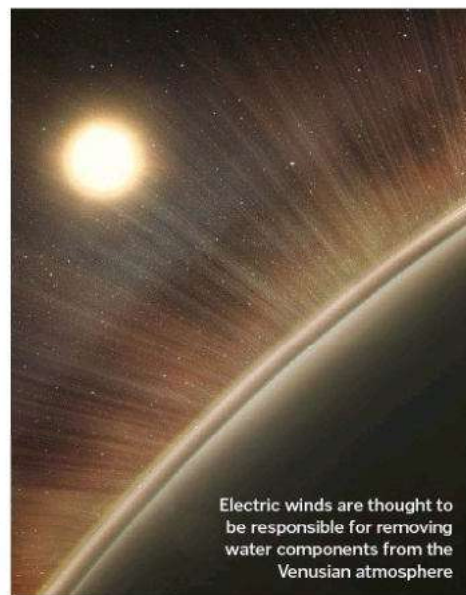
Uncovering the mystery of the planet's missing oceans

**V**enus is a hostile planet with a suffocating and crushing atmosphere, clouds of sulphuric acid and surface temperatures high enough to melt lead. Yet it is thought that the inferno planet may have been habitable for at least 2 billion years in its early history. And, though it's not a very friendly place to live anymore, ancient Venus may have had water oceans among its volcanic formations.

Entire oceans have disappeared without a trace, which had left scientists baffled until Venus' electric winds were discovered by ESA's Venus Express mission. These powerful winds are thought to be responsible for 'pushing' oxygen from the atmosphere out into space.

Every planet has a gravitational field, but it is now hypothesised that each planet with an atmosphere also has an electric field. Venus has a substantial electric field, but this was the first time one had been measured at any planet. While gravity holds the atmosphere on the planet, the electric force pushes the upper layers of the atmosphere back towards space.

This electric wind may also play an important role on Mars. NASA's MAVEN mission is orbiting the Red Planet to solve the 4-billion-year-old mystery of where Mars' atmosphere and oceans went. Understanding the role of electric wind may also help improve estimates of the size and location of habitable areas around other stars.



Electric winds are thought to be responsible for removing water components from the Venusian atmosphere





# Humpback whales

Discover the amazing anatomy of one of Earth's biggest mammals

**L**onger than a London bus and weighing more than four African elephants, humpback whales are true giants of the ocean. In the harsh conditions of the sea, humpbacks are anatomically adapted to life under the waves. As one of over ten baleen whale species, humpbacks have an interesting way of feeding. Within the whale's mouth are around 600 baleen plates made from keratin, the same protein that forms our hair and nails. These plates, together with hairs, act like a sieve through which they filter their daily consumption of around one ton of plankton, flushed in by the surrounding water.

As one of the largest mammals on Earth, these whales fill their lungs with air from a dual blowhole at the top of the head. Under the forces and pressures of the deep ocean, in order to prevent damage to an air-filled lung, their ribcages can flex. The same logic is applied to their eyesight. In order to see underwater, it's thought that the whites of the whale's eyes are thick and spongy to cope with fluctuating pressures below the surface.

## Humpback anatomy

What adaptations help these magnificent marine mammals survive?

### Baleen

Humpbacks have hundreds of baleen plates in their upper jaws, enabling them to filter out tiny fish and plankton from the seawater.

Beneath their blubber, which can be more than 40 centimetres thick after feeding all summer, lies a skeleton displaying unique signs of this whales' land-based ancestors. Whales walked on land around 45 million years ago, and vestigial bones remain within their bodies, such as the pelvis. Its prehistoric role allowed for the movement of legs long gone in modern-day whales. Other telltale evolutionary remnants in humpback's bodies are the finger bones within their pectoral fins, which resemble hands.

### Blowholes

Baleen whales have two blowholes, while toothed whales have one. Blowholes are equivalent to our nostrils and are protected by a muscular flap that forms a watertight seal.



Humpbacks are well known for their love of cetacean surfacing behaviour, or breaching

### Breach for the skies

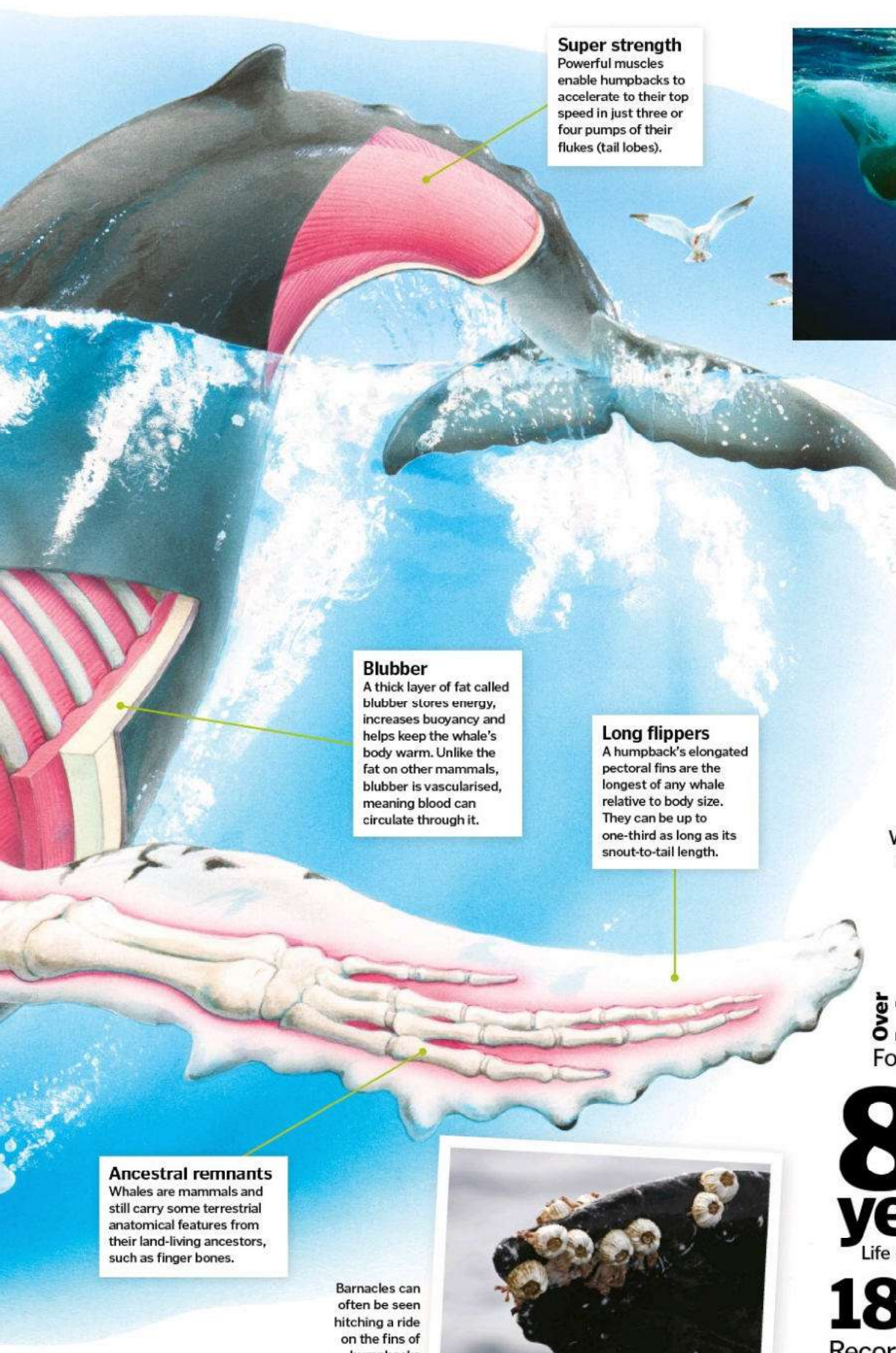
Humpbacks can leap out the water as high as their own body length. These whales have been observed to be very acrobatic compared to other baleen species, performing various leaps, slaps and charges.

*"Humpbacks are anatomically adapted to life under the waves"*

### Expandable throat

The grooves around baleen whales' throats are folds of skin that can expand to increase the volume of water gathered while filter feeding.





#### Super strength

Powerful muscles enable humpbacks to accelerate to their top speed in just three or four pumps of their flukes (tail lobes).

#### Blubber

A thick layer of fat called blubber stores energy, increases buoyancy and helps keep the whale's body warm. Unlike the fat on other mammals, blubber is vascularised, meaning blood can circulate through it.

#### Long flippers

A humpback's elongated pectoral fins are the longest of any whale relative to body size. They can be up to one-third as long as its snout-to-tail length.

#### Ancestral remnants

Whales are mammals and still carry some terrestrial anatomical features from their land-living ancestors, such as finger bones.

Barnacles can often be seen hitching a ride on the fins of humpbacks



Humpback whales have been seen to cluster, or herd, plankton shoals

### Humpback stats

**5m**

Flipper length

**Up to 18m**

Length of an average adult body

Weight of average adult **30 tons**

over **1.3 tons**  
Food consumed per day

**80 years** Life expectancy

**32 KM**  
The distance calls can travel

**18,841km**  
Record migration distance





# The birth of an iceberg

One of the largest ice shelves, Larsen C, shed a trillion tons of ice

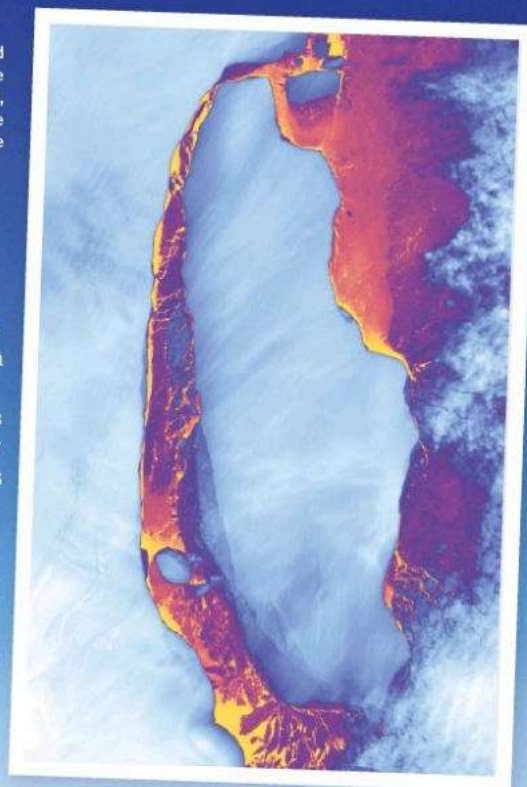
**N**amed after the Norwegian Antarctic explorer Carl Anton Larsen, Larsen C was previously the fourth largest ice shelf in the Antarctic Peninsula. But since 2014, researchers had been monitoring this icy land mass after they noticed a crack appear and spread in the shelf. Then sometime between 10-12 July 2017, the crack split the shelf. Named A68, this newly-formed iceberg weighs the same as a quarter of Wales, and its departure has reduced the size of Larsen C by about 10 per cent, dramatically reshaping the Antarctic Peninsula.

This separation event has been described as a natural event that occurs on ice sheets, though some have suggested that climate change could

be a contributing factor. As a natural process it is caused by normal temperature fluctuations from the air and sea, warming the ice and allowing it to break away. A calving of this scale, however, is unusual and could be a sign of things to come for the entire shelf. Just as Larsen A and B did in 1995 and 2002 respectively, C could be on its way to a complete melt down.

Sea level rises have been a particular concern due to the sheer size of the break away iceberg. Even so, as the iceberg was already floating on the water before being calved, it doesn't pose an immediate threat. However, glaciologists are continuing to monitor the falling ice from both Larsen and the iceberg.

Thermal infrared imaging shows the warmer areas (yellow), which act as a knife calving the coastline



UK-based project MIDAS is investigating the effects of a warming climate on the Larsen C ice shelf

The Landsat 8 satellite captured the crack and tracked its growth



© NASA / USGS Landsat / NASA / USGS / Scientific Visualization Studio / NASA / John Sonntag / NASA Earth Observatory / Joshua Stevens



**DID YOU KNOW?** The *Hyalinobatrachium dianae* glass frogs resemble the famous Muppet, Kermit

# Glass frogs

Discover the see-through skin of these amazing semi-transparent amphibians

**D**eep in the rainforests of Central and South America live a unique group of amphibians. From above, these members of the Centrolenidae family look like many other species of frog that mostly reside high up in the canopy. However, view these curious animals from underneath and you will see what makes these small frogs so special.

Glass frogs are so called because of the translucent skin that covers their stomach. The skin is so clear in some individuals that you can see the liver and intestines, and even the heart beating in their chest. The reason for this incredible feature still remains a mystery to scientists. One theory suggests it's a type of camouflage; their silhouette, when illuminated from above, is less prominent to predators lurking below while sitting on a leaf.

Unfortunately, glass frogs' semi-permeable skin makes them particularly vulnerable to environmental changes. Small rises in pollutants or toxins in their habitat can result in some areas in the rainforest being completely devoid of glass frogs. Thus, their presence in an area can be used as an indicator of a healthy ecosystem.

The lungs of some species of glass frog are also transparent

Glass frogs are small creatures, with most adults ranging from 2-3cm in length

## Why do trees shed their bark?

Find out why some trees go through a natural exfoliation process

**O**ne of the simplest reasons a tree may shed its bark is because it grows from the inside out. Bark consists of several layers. The living inner tissue (the phloem) plays an important role in transporting organic molecules around the tree. The dead outer layers (known collectively as the periderm) help in reducing water loss and protect the wood from injury and disease, similar to the role of skin in humans. This dead layer is unable to expand, therefore as the inner wood grows, the outer layer of bark expands and cracks to make room for the new bark underneath.

This process provides the tree with a number of ecological advantages; as old bark is lost,

atmospheric pollutants, parasites and fungi are also removed, helping to keep the tree healthy. Similarly, climbing plants such as vines are not able to grow as high up the tree.

Trees that shed their bark seem to do so more after hot weather, as the outer bark dries and shrinks, allowing it to peel away more easily.

The shedding of a eucalyptus trees' bark can be a fire hazard as it makes the perfect tinder



© Getty: Thibaut





# Mighty moss

How these ancient plants have thrived for millenia

**M**osses must be one of the most overlooked types of plant, but these tiny, non-flowering organisms are one of the oldest land plants known to Earth. They are thought to have first appeared in the Carboniferous period (around 358.9–298.9 million years ago) of the Paleozoic era, long before the dinosaurs, and they have remained virtually unchanged. Their spectacular survival skills have allowed this primitive plant to prosper on the planet, with their characteristic endurance reminiscent of their aquatic ancestry.

On Earth today there are approximately 12,000 species of moss, typically seen thriving as green carpet-like mats across forest floors or sprawling around tree trunks. Instead of seeds, mosses have evolved tough spores to give rise to new plants. They also lack the normal structures associated with liquid transport (the xylem and phloem) and so cannot take substances up through their roots and have no way to move liquid around the plant.

Instead, mosses rely on obtaining their water and nutrients directly by absorbing the

resources into their leaves while using thread-like rhizoids instead of roots to anchor themselves into the ground. This means that in order to thrive they need to be almost completely saturated in water.

Mosses have a special trick up their sleeve when they find themselves in unfavourable, hot conditions: they are able to almost completely halt their metabolism when stressed. By slowing their biological processes, they are able to wait patiently until water is available again and they can burst back into life.

## The lifecycle of moss

The amazing lifecycle of these plants is nothing short of a botanical marvel



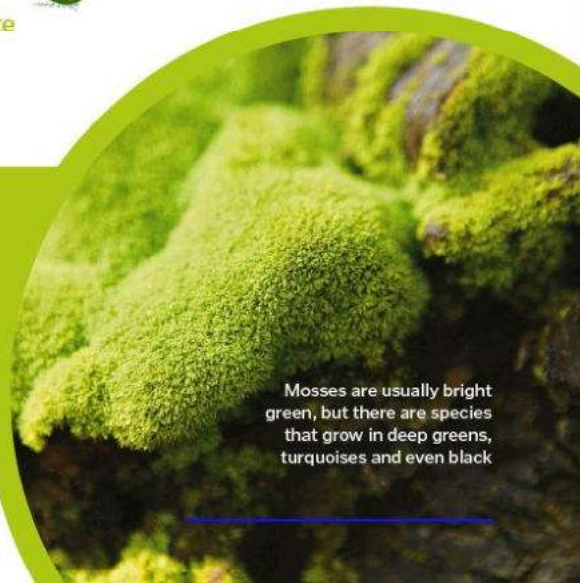
*"Moss species appeared long before the dinosaurs"*

## The many uses of moss

Mosses unique insulating and absorbing characteristics have meant we've relied on it in many parts of the world and throughout human history. Moss has been used for drinking water, decoration, food and shelter over the years.

Otzi (the famous over 5,000-year-old preserved mummy found on the Austrian-Italian border) was found with large quantities of moss stuffed in his clothes, likely for insulation, but it

could also be used as food packaging and even toilet roll. During World War I, Sphagnum mosses were used to dress wounds and stem bleeding from injuries and, if you're severely dehydrated, you theoretically could wring them out and drink the water from it. Today, we continue to harvest moss for fuel and as a soil additive, and they continue to play a large role in smoking malt to produce Scotch whisky.



Mosses are usually bright green, but there are species that grow in deep greens, turquoises and even black



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# Corfe Castle

Now in ruins, the castle once stood as a symbol of medieval might

In the Purbeck District of Dorset sits the remains of a castle built for royalty. Over 1,000 years ago, a wooden skeleton of the future stone castle stood at the top of the hill next to the village of Corfe. Built by the Saxons, it is believed this earlier version of the castle was the location of the sinister murder of the boy-king Edward the Martyr by orders of his stepmother in 978 CE.

It wasn't until the 11th century that the castle would get a rock make over, rebuilt by William the Conqueror. King Henry I commissioned the

construction of the castle's inner bailey and keep, which took between eight and nine years to complete. Made from grey Purbeck limestone, it is one of the earliest examples of an enclosed castle, with the majority of examples constructed during the 13th and 14th centuries.

The keep was surrounded by defence walls, which separated the inner and outer bailey by the 13th century during the reign of King Edward I. Royalty occupied this fortified base for around 500 years before it was sold by Queen Elizabeth I

to Sir Christopher Hatton, her Lord Chancellor, in 1572. After passing hands again to the Lord Chief Justice, Sir John Banks in 1635, the castle faced its final siege.

During the English Civil War, Oliver Cromwell ordered Parliamentarians to take control of the castle from a defiant Lady Banks, who withstood a 48 day siege in 1645. Once in control, Cromwell's soldiers dug holes packed with gunpowder, bringing the castle to its knees in an act of organised demolition.

## Inside the castle walls

A digital recreation reveals the structure of this Norman-built stronghold



### Keep

Around 21m tall, the keep would have acted as a fortified residence during a siege. The keep also housed a dungeon for prisoners in the basement.

*"Corfe is one of the earliest examples of an enclosed castle"*

### Towers

Towers along the walls of the castle offered defensive support, housing murder holes and arrow slits for soldiers to fight off advances.

### Wall

Made from Purbeck limestone, the wall perimeter acted as the first line of defence against invading forces.

### Gloriette

Built by King John circa 1201-1205, the Gloriette was the grand royal residence on which the king spent £1,400 to erect — a considerable sum at the time.

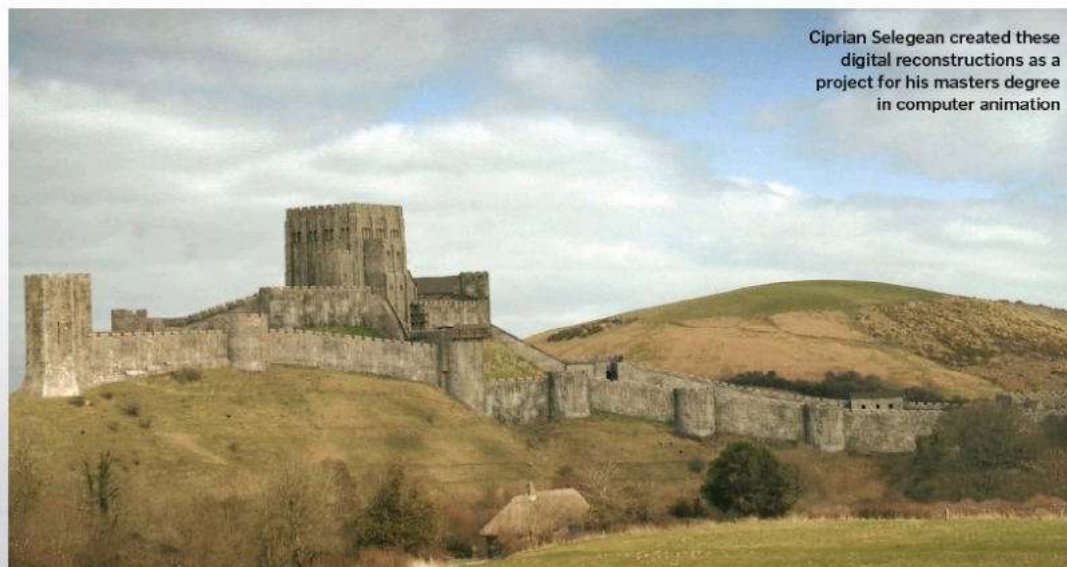
### Motte

Corfe Castle sits on a natural motte, a large mound of earth. Other castle constructions usually required a human-made motte.

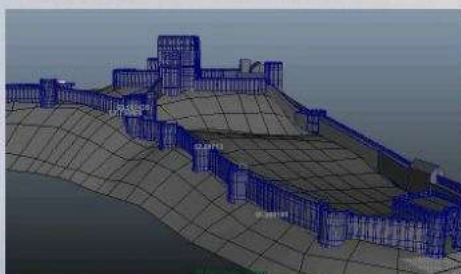


## Reconstructing the ruins

Visualising a castle long lost in ruins can be troublesome, unless of course you digitally recreate it. Ciprian Selegean, a master's graduate in computer animation from the University of Portsmouth, completed such a reconstruction. Selegean spent months researching the castle's history and drawings to construct an animated alternative. Using several software programmes, 3D modelling and texturing, Selegean was able to produce CGI models of the castle as it would have looked 400 years ago.



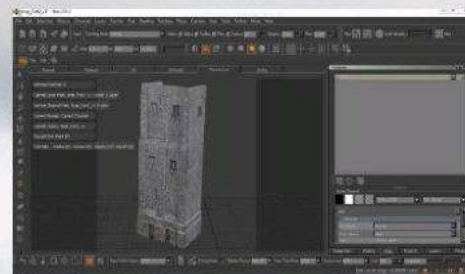
Ciprian Selegean created these digital reconstructions as a project for his masters degree in computer animation



Selegean began by creating a digital outline of the castle as it would have looked around four centuries ago



Colour and other geographical details were then added to bring the castle's surroundings to life



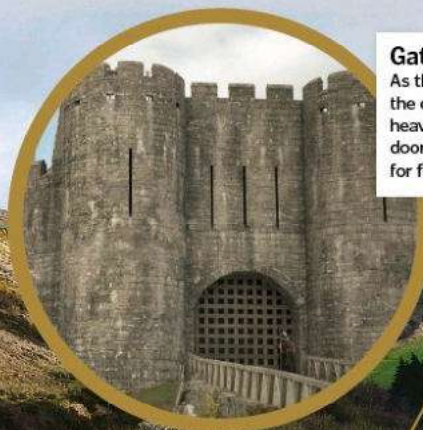
Selegean then focused on specific sections of the castle, transforming them into these detailed recreations

### Bailey

These were courtyards separated from the surrounding land and village of Corfe. These spaces housed different buildings, including a Great Hall and chapel.

### Gatehouse

As the main entrance for the castle, gates were heavily guarded and doors dropped vertically for further protection.



The ruins are now in the hands of the National Trust, after being donated by the Bankes family in 1982

© Ciprian Selegeanu, Alamy



# Sacred stones

The theories behind the mysterious Almendres Cromlech

**D**ubbed 'Portugal's Stonehenge', the Almendres Cromlech is estimated to be at least 2,000 years older than Britain's ancient attraction. The site consists of more than 90 stones arranged in two concentric circles, built in stages between 6000 and 4000 BCE.

No one is certain of its original purpose, but many believe the megalithic monument was used to observe the night sky. That's because the stones' final positions align with the spring and autumn equinox – when the days and nights are equal lengths. From the Almendres Cromlech, the Sun and Moon can be seen rising from the same point on the horizon, which suggests the

site was used by primitive astronomers.

Another theory is that the stones served religious purposes. Some of them bear carvings – serpents, crescent moons and even faces – leading some to believe they could be sculptures of ancient gods or deities. Whatever the reason or ritual, this is one of Europe's oldest megalithic complexes and an ancient spectacle.



The Almendres Cromlech site wasn't rediscovered until 1966

The stones align with the Sun during the equinoxes

# Mapping London

Uncover the story behind the famous Underground Tube map

**T**he London Tube map is iconic, but the original design was rejected for being too radical. Its designer, Harry Beck, was working as an electrical draughtsman for the Underground when he conceived this strikingly simple diagram.

Before then, Tube lines had been laid out geographically over a road map of the city. The stations were a confusing cluster in the city centre and their routes twisted and turned. Beck's design was much easier to read and could fit on a pocket-sized pamphlet. He believed commuters didn't care about the true distance between stations – they just wanted to know how to get from A to B. He was right.

So, the new Tube map was given its first full print run in 1933. Beck continued to update the diagram as new railway lines were added, and his final version was published in 1960. While the creator is relatively unknown, his map has inspired similar designs in other major cities around the world.

Harry Beck was honoured with an English Heritage plaque in 2013



**Simplicity**  
The city grid was removed to make the map easier to read.



**Artistic licence**  
Station locations are not drawn to scale: Leicester Square and Covent Garden are only 300m apart.

**Straightforward**  
Beck detangled the Tube system by using straight lines. It resembled the circuit diagrams he drew for his day job.



**DID YOU KNOW?** Over 12,000 Roman coins have been found in the Baths' Sacred Spring

Today the Roman Baths are part of a UNESCO World Heritage site



The opulent Grand Pump Room, an extension to the baths, was constructed in the 18th century

## FIVE FACTS

### 1 Water world

The Roman Baths make use of over 1 million litres of water that rises to the surface each day. This water emerges from deep underground at a temperature of around 46°C.

### 2 Royal patronage

For centuries royalty visited Bath for its supposed restorative waters, which were also thought to help with fertility. In 1687 Mary of Modena, King James II's wife, was advised to take the waters at Bath to help her conceive an heir.

### 3 Literary connection

Where the Reception Hall of the Grand Pump Room now stands was once a house belonging to writers Mary and Percy Shelley. The couple lived there in 1818.

### 4 An ancient journey

The water we see at the Baths today fell as rain on the Mendip Hills many hundreds or thousands of years ago. It travels deep through the Earth, before being heated and slowly rising again from the spring.

### 5 Iron Age origins

By the first century CE, this part of Britain was home to an ancient tribe called the Dobunni, which are known to have inhabited the area around the Bath's natural hot spring prior to the Roman invasion.

# Inside the Roman Baths

These ruins are all that is left of an ancient bathhouse, built on Britain's only natural hot spring

**T**he city of Bath takes its name from an ancient Roman spa complex, which dates back around 2,000 years. Soon after invading Britain in 43 CE, the Romans discovered a natural hot spring near the River Avon in southwest England. Delighted to find some warmth away from their Mediterranean climate, they attributed the spring to the work of Sulis, a local Celtic deity, which they identified with their own goddess Minerva. They even later named the town Aquae Sulis, or 'waters of Sulis', in honour of the deity.

The bathhouse was an important feature of any Roman settlement, providing a means to wash, relax and even socialise or conduct business. In Aquae Sulis, the Romans channelled the natural hot spring through a series of lead pipes. This provided warmth for visitors, who would navigate a series of rooms to receive different restorative treatments.

A temple dedicated to Sulis Minerva was also constructed at the site, with an adjoining Sacred Spring into which more devout visitors would throw offerings. This fed water into the Great

Bath, a large pool lined with 45 sheets of lead. Here, bathers would relax in the water at a comfortable 46 degrees Celsius.

Over the centuries the original Roman structure fell into ruin, before new buildings and pools were developed on top of the old, which became forgotten. The supposed healthy, rejuvenating effect of drinking the water from the spring drew visitors from around the world, and in the 19th century the old Roman ruins were finally re-discovered. The Baths continue to attract around 1 million visitors each year.

## BATH IN TIME

70-80 CE

The first complex dates back to soon after the Romans arrived in Britain, though natives likely already knew about the spring.

1101-1200 CE

The King's Bath is built on top of the old Roman ruin and is named after King Henry I. The Hot Bath and Cross Bath are also added later.

1706

The Pump Room is opened, providing a comfortable place for travellers to relax and take the waters. It is replaced by the Grand Pump Room 80 years later.

1878-1880

City surveyor architect, Major Charles Davis, uncovers Roman remains and large parts of the Great Bath.

2010

A £5.5 million restoration project is completed, providing public access to the ancient site and preserving its features.



# BRAIN DUMP



Because enquiring minds need to know...

## MEET THE EXPERTS

Who's answering your questions this month?

### Laura Mears



Laura studied biomedical science at King's College London and has a master's from Cambridge. She escaped the lab to pursue a career in science communication and also develops educational video games.

### Alexandra Franklin-Cheung



Having earned degrees from the University of Nottingham and Imperial College London, Alex has worked at many prestigious institutions, including CERN, London's Science Museum and the Institute of Physics.

### Tom Lean



Tom is a historian of science at the British Library where he works on oral history projects. He published his first book, *Electronic Dreams: How 1980s Britain Learned To Love The Home Computer*, in 2016.

### Katy Sheen



Katy studied genetics at university and is a former **How It Works** team member. She now works for a biomedical journal, where she enjoys learning about the brilliant and bizarre science of the human body.

### Joanna Stass



Having been a writer and editor for a number of years, **How It Works** alumnus Jo has picked up plenty of fascinating facts. She is particularly interested in natural world wonders, innovations in technology and adorable animals.



Australian scientists studied the earthy smell we experience after rain and named it 'petrichor' in 1964

## Why does the air smell different after it's rained?

Michelle Fraser

■ The distinctive smell of rain is a combination of plant oils, a compound secreted by soil-dwelling bacteria and ozone ( $O_3$ ). Damp air is particularly effective at carrying these organic compounds to our noses. Plants produce oils, which become airborne when it rains. Meanwhile, bacteria in the soil release a chemical called geosmin, a compound with an earthy scent.

Falling raindrops stir up the soil, propelling geosmin into the air, which can be detected by the human nose at a concentration of less than five parts per trillion. Finally, lightning bolts can split oxygen and nitrogen molecules in the atmosphere, and these often rearrange to form nitric oxide (NO) and  $O_3$ , which has a very sharp, chlorine-like tang to it. **AFC**

## Are any other animals monogamous?

Helen Cross

■ There are examples of monogamy throughout the animal kingdom. Gibbons, swans and black vultures are all known to pair up with a single partner, although infidelities do occasionally happen. Wandering albatross couples meet up every two years to breed, but one in ten of a female's chicks may be fathered by an outsider. Prairie voles form lifelong bonds and often remain committed even if their partner dies, with fewer than 20 per cent seeking a new mate. **KS**



## Want answers? Send your questions to...

How It Works magazine @HowItWorksmag [howitworks@futurenet.com](mailto:howitworks@futurenet.com)





## Could we ever travel at the speed of light?

As far as we know, travel at the speed of light is simply impossible

Sean Williams

■ According to Einstein's Theory of Special Relativity, it's impossible for any object with mass to reach the speed of light. Accelerating a spaceship requires energy; the faster the spaceship travels (ie the more energy it has), the

greater its mass, so the amount of energy required to speed it up any further increases. Accelerating the spaceship to the speed of light would therefore require an infinite amount of energy, making it impossible. **AFC**



## Why is the ISS going to be decommissioned? Nel Parker

The International Space Station (ISS) is scheduled to stay in service until at least 2024, with a possibility to extend operation until 2028. This is to free up NASA's budget for new projects, such as exploring Mars. NASA currently spends roughly \$3 billion (approximately £2.2 billion) every year on running its share of the ISS. **AFC**



## What is the oldest known competitive sport?

Jenson Clayton

Running is thought to be the world's oldest sport. The stade race, a 192-metre foot race, was the only sport featured at the very first recorded Olympic Games in 776 BCE. **JS**



## Where do petrol stations store their petrol? Micky Lindt

Petrol stations usually store their fuel in giant tanks buried underneath the forecourt, which are filled up from gas tankers. Each one can hold several thousand gallons of fuel, which is then pumped up to the petrol dispenser using a submersible or suction pump. **JS**



## How effective are plastic bag charges? Nicole Jennings

Single use plastic bag charges have been introduced in several countries, including Italy and South Africa. Since a five pence charge was introduced in England in 2015, plastic bag use has fallen by more than 80 per cent. **KS**

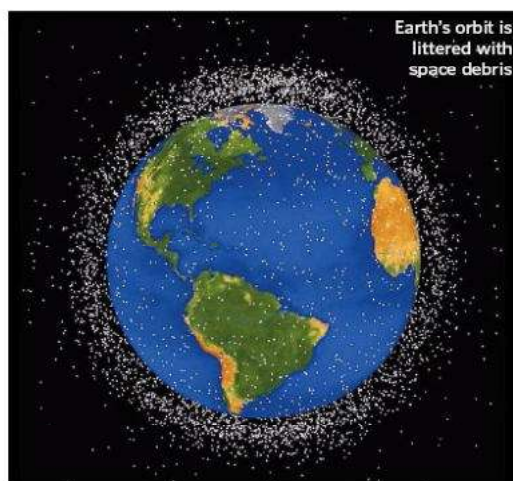
## What is the youngest island?

Harriet Gregory

■ Our planet's newest island is Shelly Island, a sand bank that started to form off the coast of North Carolina in April 2017. However, recent storms, such as Hurricane Maria, have now washed away most of this tiny island. **AFC**



Locals nicknamed the island 'Shelly' due to the amount of shells found on its shores



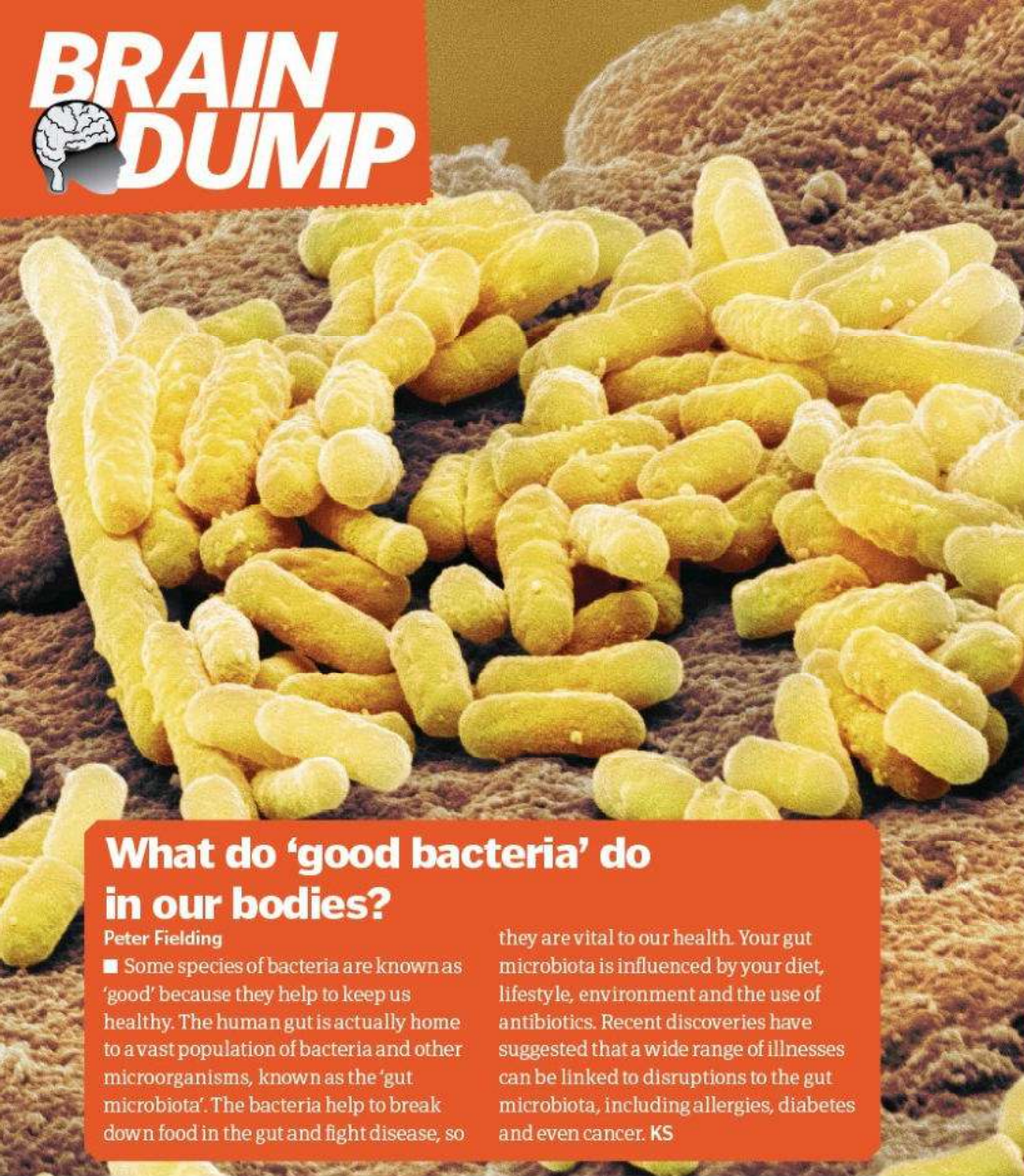
Earth's orbit is littered with space debris

## Do satellites ever collide in space?

Vanessa Harris

■ They do, but very, very rarely. There's a lot of space in space and so the distance between the satellites orbiting Earth is usually quite vast. They also all travel in the same direction at similar speeds so there is only a very slim chance that they will come into contact with each other. The last major satellite collision occurred in 2009, when an active American satellite collided with a defunct Russian satellite, smashing them both into pieces. **JS**





## What do 'good bacteria' do in our bodies?

Peter Fielding

■ Some species of bacteria are known as 'good' because they help to keep us healthy. The human gut is actually home to a vast population of bacteria and other microorganisms, known as the 'gut microbiota'. The bacteria help to break down food in the gut and fight disease, so

they are vital to our health. Your gut microbiota is influenced by your diet, lifestyle, environment and the use of antibiotics. Recent discoveries have suggested that a wide range of illnesses can be linked to disruptions to the gut microbiota, including allergies, diabetes and even cancer. KS

## Why is yawning sometimes contagious?

Danny Thomas

■ Yawning is thought to be the body's method of cooling the brain to optimum working temperature. The stretching of our jaw increases the rate of blood flow to the brain and inhaling air reduces the temperature of that blood flow. The act of yawning can be contagious in social animals such as humans, primates and even dogs, and the reason for this is most likely related to empathy — our ability to understand and feel emotions. JS

Yawning is more likely to be contagious for those with lots of empathy for others



## Which flowers are bees most attracted to? Tim Rowley

Although you might expect bees to prefer the brightest flowers in a garden, research shows that their favourites are actually aromatic plants, including oregano and certain types of lavender. These plants are a good source of pollen and nectar, of which the bees collect by perching on petals and inserting their proboscis into the flowers. KS



## How do astronomers keep track of near-Earth objects?

Florence Sole

They use something called a 'charged couple device', which takes pixelated images of the same patch of sky every few minutes. Then they compare the images to spot objects that have moved. LM



## Why are dental records used to identify bodies? Harry Kinson

Teeth are tough and last much longer than soft tissues after people die. And, like fingerprints, everyone's mouths are different. The shape of the teeth and jaw can tell us about a person's age and sex, and unique characteristics like fillings, can help to identify them. LM



## What does LCD stand for?

Steve Moss

Electronic displays use liquid crystal molecules, which are able to adjust the amount of light to form the images we see displayed. So LCD stands for Liquid Crystal Display. TL





## What makes certain fabrics 'breathable'?

Keri Yates

■ Breathability is a measure of how easily water vapour can move through a fabric. We cool down by sweating, and breathable fabrics allow evaporated liquid to circulate and escape. Whether a fabric is breathable depends on the fibre and the weave. Natural fibres, like cotton and linen, draw liquid away from the skin, whereas synthetics, like polyester, tend to repel water. Open weaves with lots of holes allow air to circulate, while tight structures stop the air flow. LM

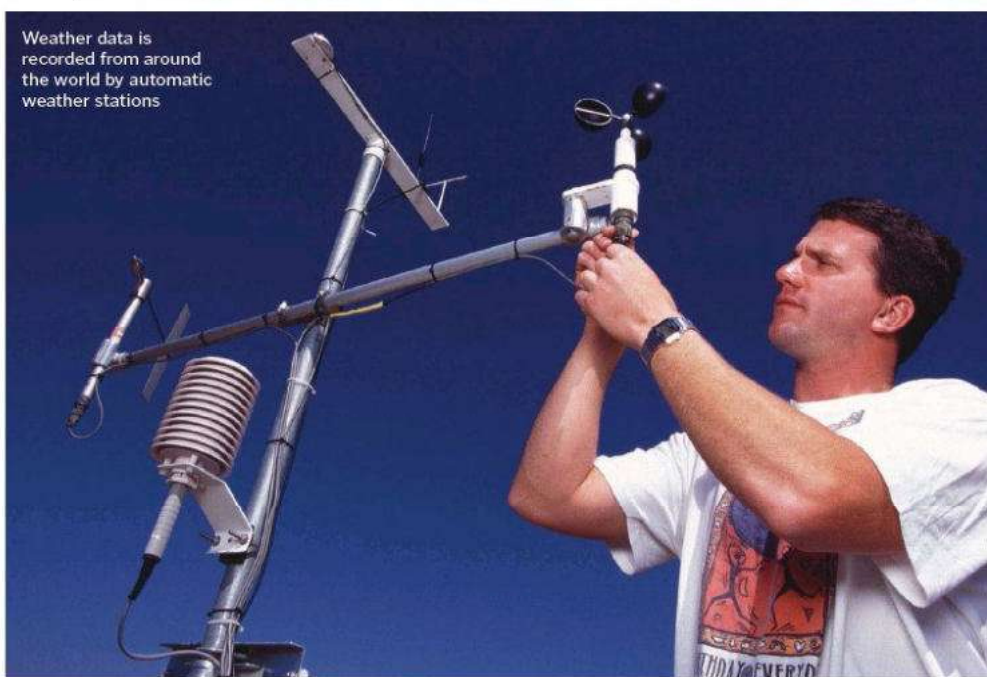
Wool contains lots of trapped air, allowing water vapour to circulate

## When did official weather records begin?

Tom Wilson

■ Amateur meteorologists have recorded the weather for centuries, but it was only in the mid-1800s that this became official. In 1854 the British government set up the Meteorological Department, which later became the Met Office. Several other countries set up national weather services to record and forecast the weather in this time period too. The problem was that they used different methods, which only gradually became standardised, hence the Met Office today only has reliable weather records from 1914. However, by analysing historical records, ice cores, fossils and other sources, scientists can estimate the weather conditions far further back in time. TL

Weather data is recorded from around the world by automatic weather stations



## Where did the idea that black cats are bad luck come from?

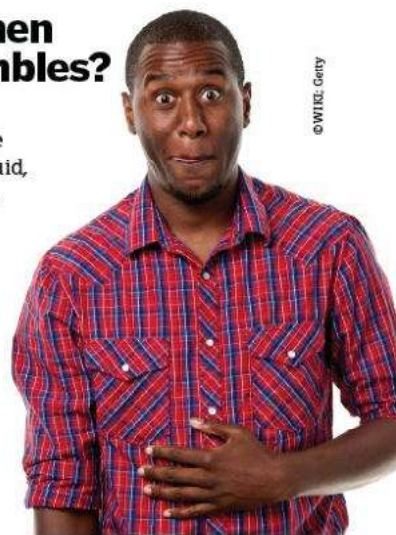
Marc Alonso

■ In the West, much of the superstition about black cats bringing bad luck seems to be due to their association with stories of witches and black magic. However, there are many different superstitions about cats, and in some cultures black cats are actually seen as good luck. TL

## What happens when your stomach rumbles?

Thom Hartnett

■ Your stomach and intestines have muscles that push food, gas and liquid, through your digestive system. The rumbling sound occurs as food is squeezed by the muscles. When you have an almost empty stomach, your brain orders the muscles to push along anything that's left, causing the rumbling sound you hear. TL



© WIRE Getty



# BOOK REVIEWS

The latest releases for curious minds

## Robot Wars: Build your own Robot

Roboteers, stand by

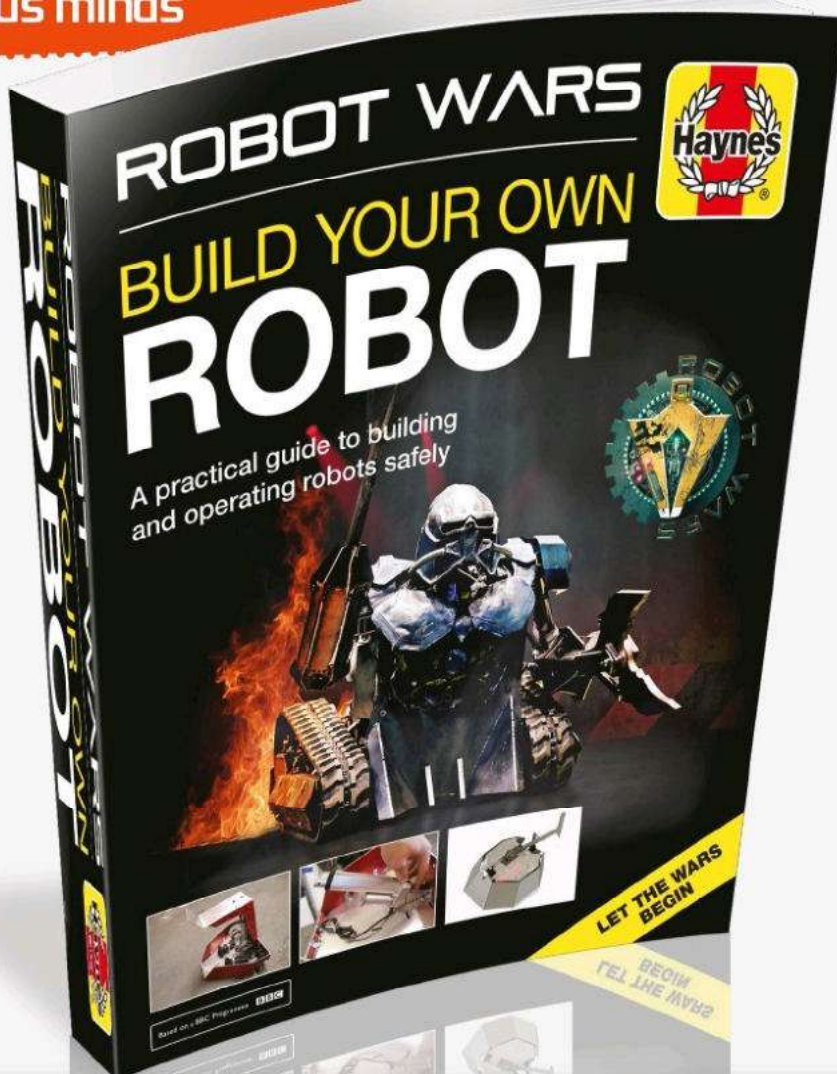
■ Author: James Cooper  
■ Publisher: Haynes  
■ Price: £22.99 / \$29.99  
■ Release date: Out now

**H**ands up who is a massive fan of *Robot Wars*, the BBC's mech mash-up that sees homemade metal monsters scrapping it out on the arena floor. Keep your hands up if you ever thought, 'I want to make my own.' Now, did you ever actually follow through? No? That's okay, making a robot takes time and money and is unsurprisingly a lot harder than it looks.

Not content with regularly putting together the kind of concise, informative and lovingly presented handbooks that have become a staple of many a birthday or Christmas gift-giving session over the years, Haynes has turned its attentions to making your childhood dreams come true by releasing this very fine guide to creating your own metal masterpiece. That's right, you too can finally duke it out with the likes of Sir Killalot, Matilda, Shunt and Dead Metal — or see them spread your metal entrails across the arena.

Needless to say, nothing worth doing is ever easy, and while this book goes to great lengths to instruct you on the art of robot craftsmanship, this is no beginner's guide. While it does hold your hand, a basic knowledge of what's required is a must, and it's worth bearing this in mind before you buy.

**"You can finally duke it out with the likes of Sir Killalot, Matilda and Dead Metal"**



But if you choose to dive in, there's plenty of information to ensure that no stone is left unturned. From fact files about the show's house robots (and how they work) to the basic parts required, assembly guides, safety tips and a substantial glossary of terms (considering just how much detail is involved, this is especially vital), it's as if Haynes is determined that you bring to life your very own robotic Frankenstein.

Also intriguing is some of the information disclosed in this book. Ever wondered why more contestants didn't try to take on Sir Killalot at his

own nefarious game? Turns out that each one of his mobile drive pods weighed more than the maximum weight allowance for each competitor, so it really wouldn't have been worth the risk.

But, even if you don't get around to building your own robot after reading this, you will still glean a lot from this book, both in terms of acquired knowledge and appreciating the level of work that goes into all areas of the show. Welcome back, childhood.

★★★★★



# Built: The Hidden Stories Behind our Structures

Towering achievements

- Author: Roma Agrawal
- Publisher: Bloomsbury
- Price: £20 / \$28
- Release date: 8 February 2018 (UK) / 13 February 2018 (US)

The impact that architectural engineers have on our lives is both obvious and understated in equal measure. Sure, the results of their handiwork are clear to see in the towering examples that represent some of the world's most renowned buildings, but at the same time it doesn't tell the story of the level of work that goes into them. Luckily, we have *Built: The Hidden Stories Behind our Structures* to do that job.

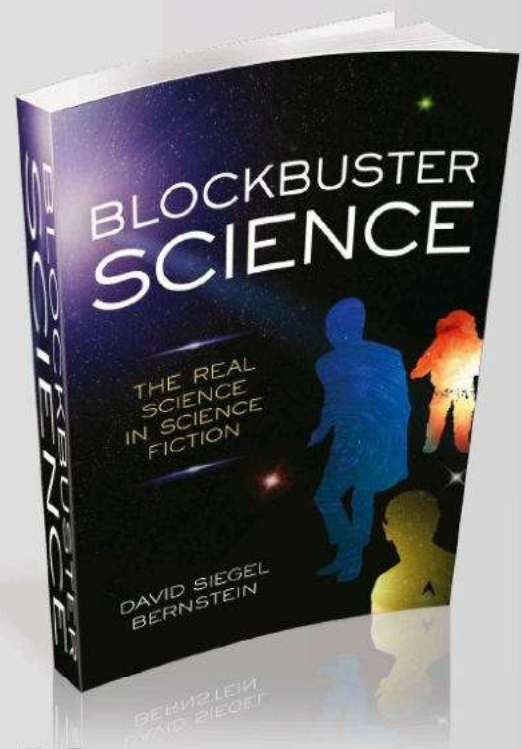
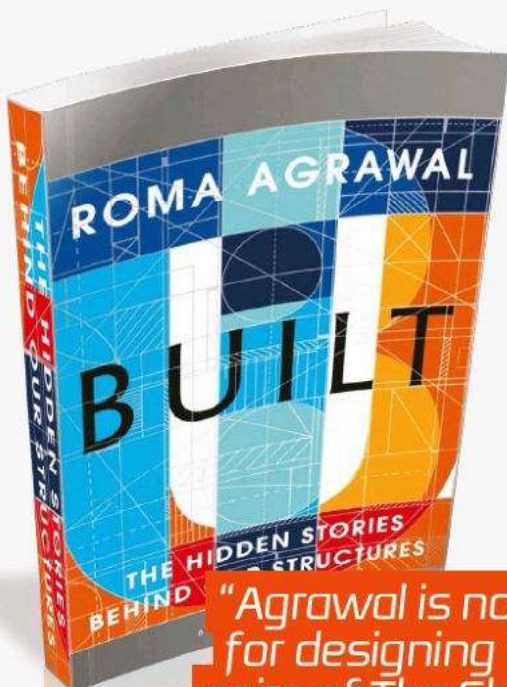
Penned by Roma Agrawal, most noted for designing the foundations and spire of The Shard, we're presented with a tale as old as time; how have buildings have evolved from humble mud huts to some of the goliaths we see today and some of the feats that

have been achieved to make this possible. Agrawal draws on her own experiences to great effect, with some of her own illustrations forming a backdrop to the points she makes.

At one point she describes an engineer's job as "plate-spinning", which proves to be a massive understatement when you consider the level of responsibility and accountability involved, especially in light of certain disasters she brings up.

By framing this almost as a story, Agrawal ensures that the narrative is engaging and easy to follow and thus brings a high level of clarity to a potentially dense subject matter.

★★★★★



## Blockbuster Science: The Real Science in Science Fiction

Far-away galaxies laid bare

- Author: David Siegel Bernstein
- Publisher: Prometheus Books
- Price: £21 / \$24
- Release date: Out now

As much we love *Star Wars*, *Star Trek* et al, it's a sad fact that much of what their fictional universes depict simply isn't possible and likely never will be.

Even so, everything has a basis in fact somewhere, which is where David Siegel Bernstein comes in with *Blockbuster Science*, which uses the likes of *Ender's Game*, *The Hitchhiker's Guide To The Galaxy*, *Planet Of The Apes* and numerous other science fiction media as case studies to examine the real science behind the impossible feats of space travel and other such wonders that we all love to watch. As far as plans for encouraging more people to engage with science goes, it's a pretty good call.

However, the results are rather mixed. A lot of the time it simply

feels like the references to the assorted pop-culture likenesses have been tacked on, providing unnecessary amendments in the grand scheme of things. Moreover, often the stories are so fantastical — which is hardly their fault considering they don't exactly hide their fictional nature — that they can get in the way of any actual science lessons, so it can feel like you're not learning that much.

In fairness, aspects of this are very enjoyable — fans will get a kick out of seeing their favourite shows and films getting name-dropped — but apart from that there isn't really much more to be gained from either watching the subject in question or reading up on the topic elsewhere.

★★★★☆



## 3D Printing Projects: Amazing Ideas to Design and Make

Discover the diverse world of 3D printing

- Author: DK
- Publisher: DK
- Price: £9.99 / \$14.99
- Release date: Out now

3D printing has revolutionised the product development industry, but now it's time for this technology to provide a bit of fun. From simple desk tidies to complex castles, this how-to guide to 3D printing details 14 interesting and adaptable designs for you to recreate.

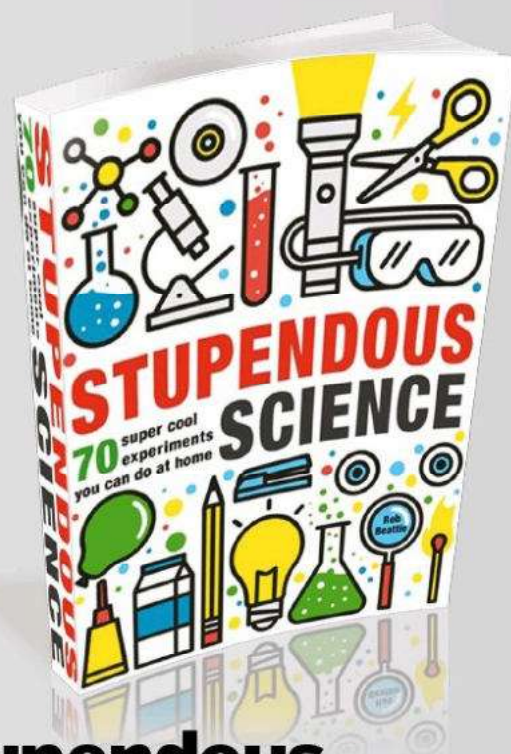
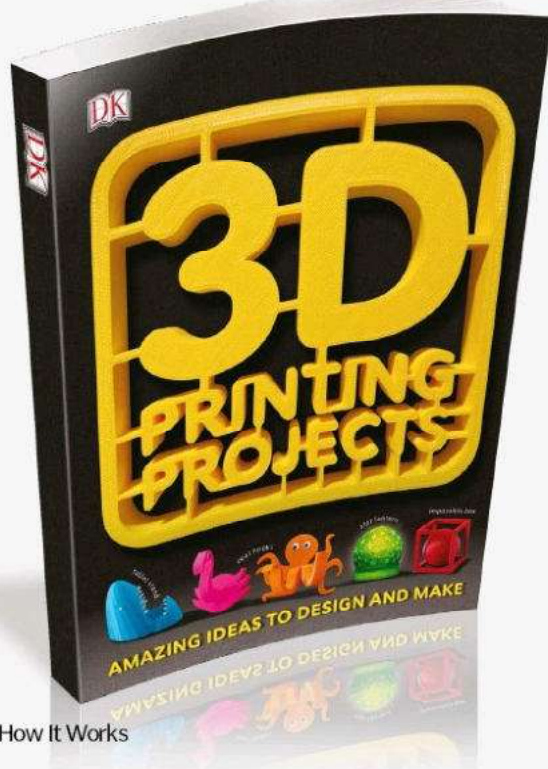
This book offers an excellent general insight into how 3D printing works, including top tips and troubleshooting solutions. An informative introduction provides the reader with suggestions for online software and an overview of what to expect from start to finish. Covering the printer technology, slicing, 3D/organic

modelling and after-print treatments, this book is the perfect accompaniment for a first-time enthusiast.

Easy-to-follow steps in each design process will help readers to keep track of what they are designing. Aimed at those aged ten or above, the designs range in difficulty, so there is something for those that want to test themselves and also those just having fun.

★★★★★

*"This offers an excellent insight into 3D printing"*



## Stupendous Science: 70 Super Cool Experiments You can do at Home

Finding the science in everyday objects

- Author: Rob Beattie & Sam Peet
- Publisher: QED Publishing
- Price: £10.99 / \$12.95
- Release date: Out now

While the simplest science experiments can be the most impressive, *Stupendous Science* showcases some that will completely blow your mind.

We've all heard of the classic experiments such as making slime and the baking soda and vinegar volcanoes that you can do at home, but what about the electronic lemon, the vanishing rainbow or the solar oven?

Fortunately, you won't need to rush out and spend a great deal of money on supplies for these experiments—the items that you will need are mostly household objects. However, you might want to get some safety goggles, as these

will come in handy for the fountain of foam that will erupt when you're making elephant's toothpaste.

Not only have Beattie and Peet displayed some truly super science here; this book is stupendous in its design too. Each page is beautifully illustrated with fun and colourful designs, regular bursts of colour that perfectly complement this explosion of science.

Easy to follow, this instructional guide to science provides children (and adults if they wish) with an opportunity to learn about biology, chemistry and physics, all while having some fun. Now that's what science should be about.

★★★★★



## Citizen Science

A humorous insight into the citizen scientists who are revolutionising the way we conduct research

- Author: Caren Cooper
- Publisher: Duckworth Overlook (UK) / The Overlook Press (US)
- Price: £14.99 / \$28.95
- Release date: Out now

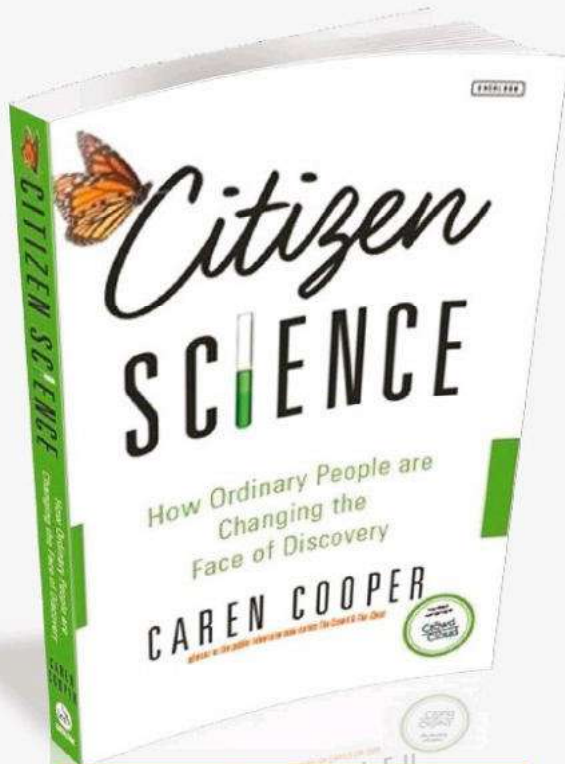
You might think that you need to be a scientist to participate in innovative research around the globe. However, Caren Cooper's book demonstrates that this is definitely not the case.

Citizen scientists are highly valuable members of the scientific community, and make a huge difference to the projects they work on by sampling and reviewing data that would otherwise take scientists a great deal of time to get through. From astrology to zoology, there are millions of people without

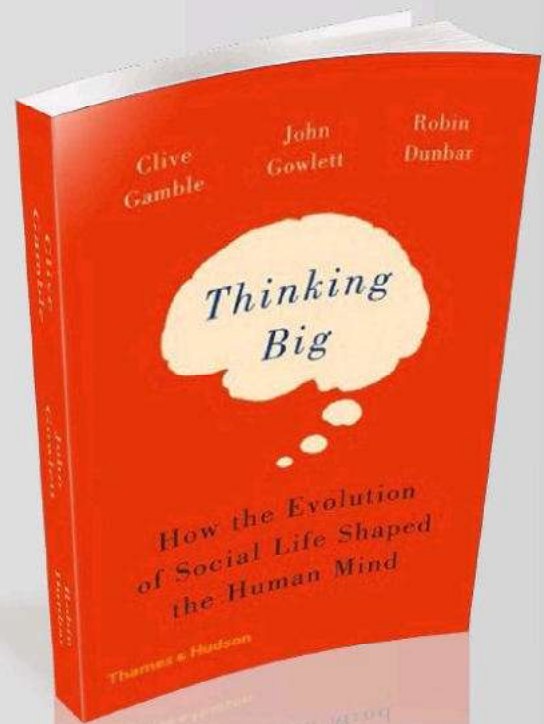
scientific qualifications who are an integral part of our growing body of knowledge.

Cooper brings the world of citizen science into view and tells the stories of the people who are getting involved. The citizen science movement is powered by the drive of individuals who want to discover, and Caren Cooper's guide to this way of working together to contribute to scientific understanding is a fantastic examination of the work going on behind the scenes.

★★★★★



"Citizen scientists are highly valuable members of the scientific community"



## Thinking Big

Find out how our social lives shaped our brains

- Author: Clive Gamble, John Gowlett, Robin Dunbar
- Publisher: Thames & Hudson
- Price: £9.99 / \$16.95
- Release date: Out now (UK) / 6 February 2018 (US)

Authored by evolutionary psychologist (Dunbar) and two archaeologists (Gamble and Gowlett), this book is the result of a superb combination of expertise enabling the reader to understand the theories behind our evolution and the hard evidence that supports them.

This extensive investigation explores the history of our brain, and the growth of this big-thinking, social computer. And, although the human and chimp lineages diverged approximately 7 million years ago, we still appear to carry instinctively social habits within our ancient minds. In just tens of thousands of years, we have gone from using stone tools to iPhones, but our social lives at the basic level have hardly changed. We are now global citizens, with many of us living in megacities, yet we still possess ancient minds only capable of maintaining contact with a

limited natural social group of around 150 (so-called Dunbar's number) individuals.

The authors brilliantly illustrate the differences and similarities between modern humans, our ancestors and our primate relatives, using informative graphs and captivating images to display the geometric patterns etched into rocks, as well as including fossil records of our origins and drawings of our oldest forbearers.

This book is a fantastic read for anyone interested in evolutionary biology and archaeology, particularly if you've always wondered about your own instincts. Why does an audience laugh in ripples rather than all together, and why do we line up the glasses on the table with lines on the checkered table cloth? A host of questions are answered within these pages.

★★★★★



# BRAIN GYM

GIVE YOUR BRAIN A PUZZLE WORKOUT

## Wordsearch

D	I	A	S	T	R	O	M	E	T	R	Y	B	R	W
G	B	X	G	Q	U	K	C	A	B	P	M	U	H	O
O	W	A	O	A	C	Y	E	R	T	N	L	O	P	R
N	E	A	R	V	R	B	Z	S	U	L	H	B	I	L
D	I	V	F	K	T	T	C	E	F	M	X	Q	U	D
O	C	B	Y	I	L	I	P	A	R	U	T	B	H	W
L	E	A	O	L	H	G	K	M	S	S	N	A	T	I
A	B	Y	Q	P	O	H	T	P	A	T	I	S	A	D
U	E	L	A	M	V	T	C	L	V	A	L	T	B	E
E	R	R	H	A	N	R	J	T	E	N	E	E	N	W
X	G	G	C	E	W	O	P	O	N	G	M	R	A	E
S	E	S	S	O	M	P	G	E	U	R	U	O	M	B
C	V	K	I	E	C	E	L	L	S	R	U	I	O	Y
D	N	U	O	R	G	R	E	D	N	U	M	D	R	N
Q	X	B	R	E	A	T	H	P	R	I	N	T	V	R

### FIND THE FOLLOWING WORDS...

BARK  
ICEBERG  
MOSES  
UNDERGROUND  
BREATHPRINT  
ASTEROID  
GRAPHICS  
WORLDWIDEBE  
GONDOLA  
MUSTANG  
TIGHTROPE  
CASTLE  
HUMBACK  
ASTROMETRY  
ROMANBATH  
CELLS  
VENUS  
FROGS

## Quickfire questions

**Q1** The Roman numeral X represents which number?

- ☐ 5
- ☐ 10
- ☐ 50
- ☐ 100

**Q2** Which was the first James Bond film?

- ☐ *Dr No*
- ☐ *Casino Royale*
- ☐ *Goldfinger*
- ☐ *From Russia with Love*

**Q3** What is the average distance between Earth and Mars?

- ☐ 50mn km
- ☐ 50bn km
- ☐ 225mn km
- ☐ 225bn km

**Q4** What is the capital city of Canada?

- ☐ Toronto
- ☐ Montreal
- ☐ Ottawa
- ☐ Vancouver



## Spot the difference

See if you can find all six changes we've made to the image on the right







## BEAT THE TEAM... SUDOKU & NUMBER SQUARES



Jackie

### SUDOKU

Easy left: 02m 09s  
Easy right: 03m 38s  
Medium: 04m 25s  
Hard: 12m 50s

### NUMBER SQUARES

Left: 03m 28s  
Right: 07m 27s  
Total time:  
33m 57s



Scott

### SUDOKU

Easy left: 03m 11s  
Easy right: 03m 31s  
Medium: 05m 03s  
Hard: 13m 14s

### NUMBER SQUARES

Left: 04m 01s  
Right: 08m 34s  
Total time:  
37m 34s



Charlie

### SUDOKU

Easy left: 03m 17s  
Easy right: 04m 01s  
Medium: 05m 30s  
Hard: 13m 41s

### NUMBER SQUARES

Left: 04m 06s  
Right: 09m 13s  
Total time:  
39m 48s



Duncan

### SUDOKU

Easy left: 04m 01s  
Easy right: 04m 12s  
Medium: 05m 55s  
Hard: 13m 58s

### NUMBER SQUARES

Left: 04m 56s  
Right: 10m 02s  
Total time:  
43m 04s



Charlie

### SUDOKU

Easy left: 02m 26s  
Easy right: 03m 55s  
Medium: 05m 04s  
Hard: 12m 58s

### NUMBER SQUARES

Left: 03m 35s  
Right: 08m 01s  
Total time:  
35m 59s



Baljeet

### SUDOKU

Easy left: 02m 42s  
Easy right: 03m 34s  
Medium: 04m 55s  
Hard: 11m 47s

### NUMBER SQUARES

Left: 03m 43s  
Right: 08m 01s  
Total time:  
34m 42s



Laurie

### SUDOKU

Easy left: 03m 05s  
Easy right: 03m 52s  
Medium: 05m 26s  
Hard: 13m 38s

### NUMBER SQUARES

Left: 04m 10s  
Right: 09m 20s  
Total time:  
39m 31s

## HOW DID YOU DO?

Fill in your times to  
try and beat us!

### SUDOKU

Easy left: \_\_\_\_\_  
Easy right: \_\_\_\_\_  
Medium: \_\_\_\_\_  
Hard: \_\_\_\_\_

### NUMBER SQUARES

Left: \_\_\_\_\_  
Right: \_\_\_\_\_  
Total time: \_\_\_\_\_

# Sudoku

Complete the grid so that each row, column and 3x3 box contains the numbers 1 to 9. See if you can beat the team!

## EASY

5	6		7			2	9	8
7	8			9	2	5	1	
				4				
	2		3	1		7		9
1	9	5	2	6	7		4	3
8		7		4		1		2
3	5	8	4			9		
6	4	2		7	9	3	8	5
9	7		5	8				6

## EASY

4		8	7	6				1
7	6	1	2	8	5	9	3	
		2	1					8
3		9	6	5	1			
1	2		8	9	7		5	3
6			3	4		1		
9	5			1		8		
8		7	9	2		3	1	5
	1			7	8	4	9	6

## MEDIUM

9	2				5			8
	8			7	1			
3			6	8	2	7	9	
7		9	3			8		
						9	5	
	3		8	5		6		1
		2	7	6		3		
				2			4	
	1			8				7

## HARD

						3		9
7			3				5	
	6		2			8		4
	8					1		6
	3			5	2			
				4				
		5				4		
3	4		8			9		1
9			1					7

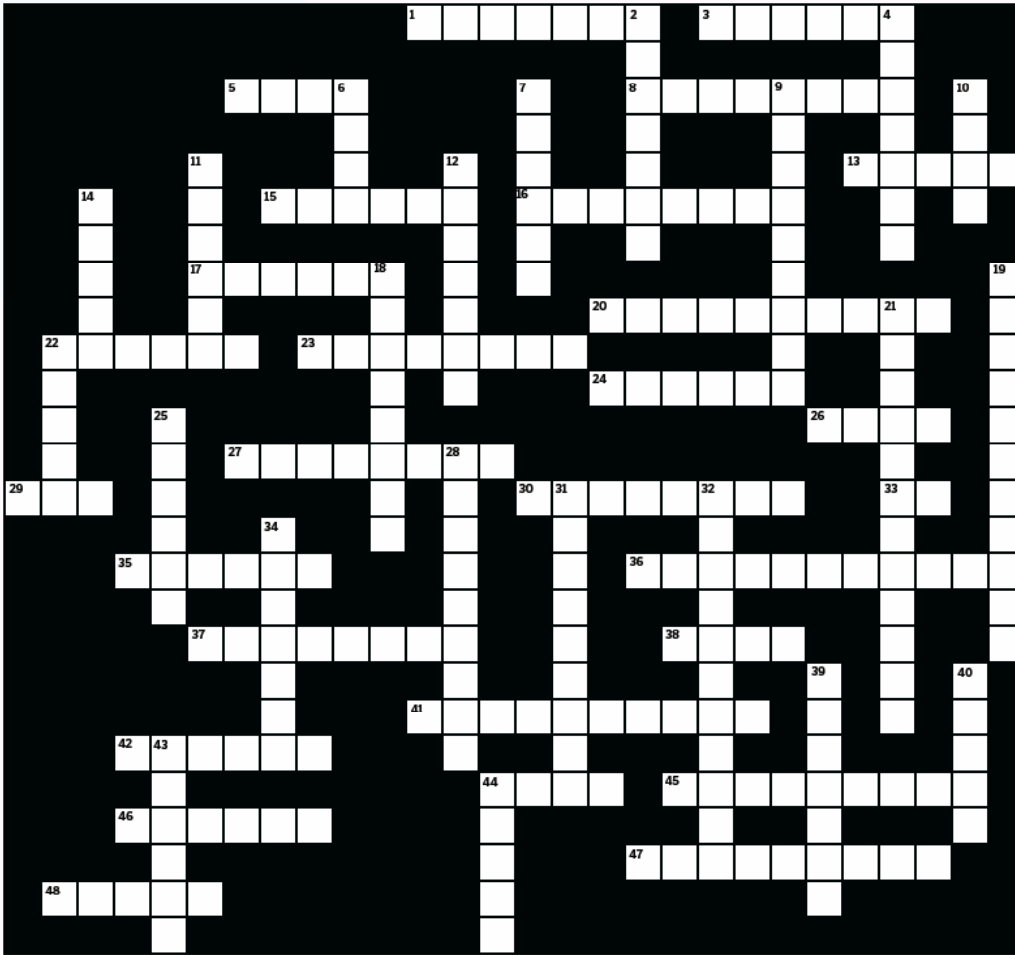
# Number squares

Complete the grid by multiplying the values in the rows and columns. Time yourself and see if you can beat the team!

x	1	9	5	6	2	10	7	3	4	8
10										
2										
6										
9										
7										
1										
8										
3										
4										
5										

x	20	17	14	13	15	16	12	18	19	11
1										
2										
5										
8										
4										
9										
10										
3										
7										
6										





## Crossword

### ACROSS

- 1 Name for the North Star (7)
- 3 Botanically a legume, but widely considered a nut (6)
- 5 A pollution-mixed fog (4)
- 8 Famous physicist who developed theory of relativity (8)
- 13 Computer device; rodent (5)
- 15 Precious metal, chemical symbol Ag (6)
- 16 The programs used by a computer (8)
- 17 The northernmost ocean (6)
- 20 The vehicle providing power for a train (10)
- 22 Hot spring where water intermittently spews out in a tall column (6)
- 23 General of Carthage, almost conquered Rome (8)
- 24 Relating to dogs; sharp tooth (6)
- 26 Smallest unit of a chemical element (4)
- 27 The world's largest species of tiger (8)
- 29 Mauna \_\_\_\_, Earth's tallest mountain measured from base to peak (3)
- 30 The geological period lasting from circa 200-145 million years ago (8)
- 33 Jupiter's innermost Galilean moon (2)
- 35 Largest unit of the Roman army (6)
- 36 The collective term used for Norway, Sweden and Denmark (11)
- 37 The world's largest living rodent (8)
- 38 Where the Large Hadron Collider is (acronym) (4)
- 41 Instrument to make very small objects appear larger (10)
- 42 The former name of Ho Chi Minh City in Vietnam (6)
- 44 The scientific institute looking for intelligent life in the universe (acronym) (4)

- 45 A sudden vertical drop in the course of a stream or river (9)
- 46 Earth's thickest layer, contains molten and semi-molten rock (6)
- 47 The site of a nuclear disaster in 1986 (9)
- 48 Relating to or determined by the Sun (5)

### DOWN

- 2 A design to make radar or sonar detection difficult (7)
- 4 The flexible collagen cords attaching muscles to bones (7)
- 6 Large, white-grey birds that live near the sea (4)
- 7 Vin \_\_\_\_, actor and star of the *Fast & Furious* films (6)
- 9 Device for making calls (9)
- 10 Reddish coating of Iron oxide (4)
- 11 A long journey, typically by sea or in space (6)
- 12 Battle of \_\_\_\_, July-Oct 1940 (7)
- 14 \_\_\_\_ numbers, only divisible by either one or themselves (5)
- 18 British-French supersonic commercial airliner (8)
- 19 Large recreational area in New York City (7,4)
- 21 Small dinosaur of late Cretaceous; album by Kasabian (12)
- 22 Shape of the Earth (5)
- 25 Element needed for respiration (6)
- 28 Romanov princess; 1997 animated film (9)
- 31 Fastest man on Earth (5,4)
- 32 Renowned playwright, poet & actor; the Bard of Avon (11)
- 34 An underwater missile (7)
- 39 Term for an Ancient Egyptian king or queen (7)
- 40 Serbian-US engineer and inventor, Nikola \_\_\_\_ (5)
- 43 The highest-grossing motion picture in history (6)
- 44 The native Dakota people of North America (5)

**Q5** In which one of the following countries do people drive on the left-hand side?

- ☐ Mexico
- ☐ Japan
- ☐ Brazil
- ☐ Morocco

**Q6** What is the name of Google's parent company?

- ☐ Numberwang
- ☐ Microsoft
- ☐ Mars
- ☐ Alphabet

**Q7** 'Graffiti' is derived from the Italian for...

- ☐ Scratched
- ☐ Marked
- ☐ Messed
- ☐ Vandalised

**Q8** The Beatles were...

- ☐ John, Paul, James and George
- ☐ John, Peter, Ringo and Martin
- ☐ John, Paul, Ringo and George
- ☐ John, Paul, George and Martin

**Q9** Approximately how many people globally watched the Apollo 11 Moon landing?

- ☐ 53-60 million
- ☐ 1-1.2 billion
- ☐ 66-70 million
- ☐ 530-600 million

**Q10** A supermoon can appear up to \_\_\_\_% bigger than an average Moon

- ☐ 7%
- ☐ 24%
- ☐ 30%
- ☐ 52%



# What is it?

Can you identify the three images below?



A \_\_\_\_\_



A \_\_\_\_\_

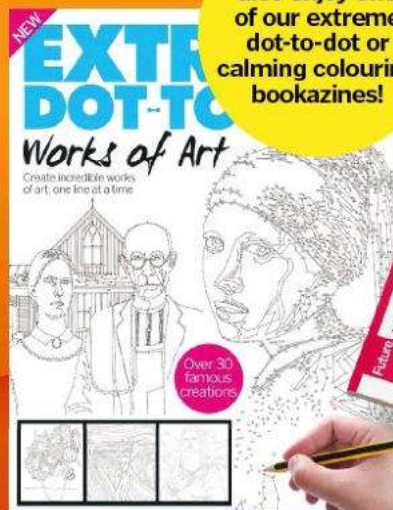
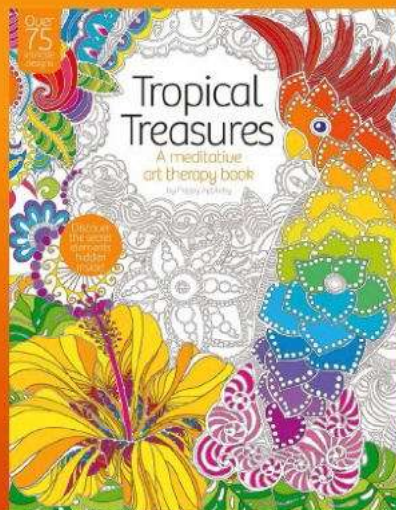


A \_\_\_\_\_

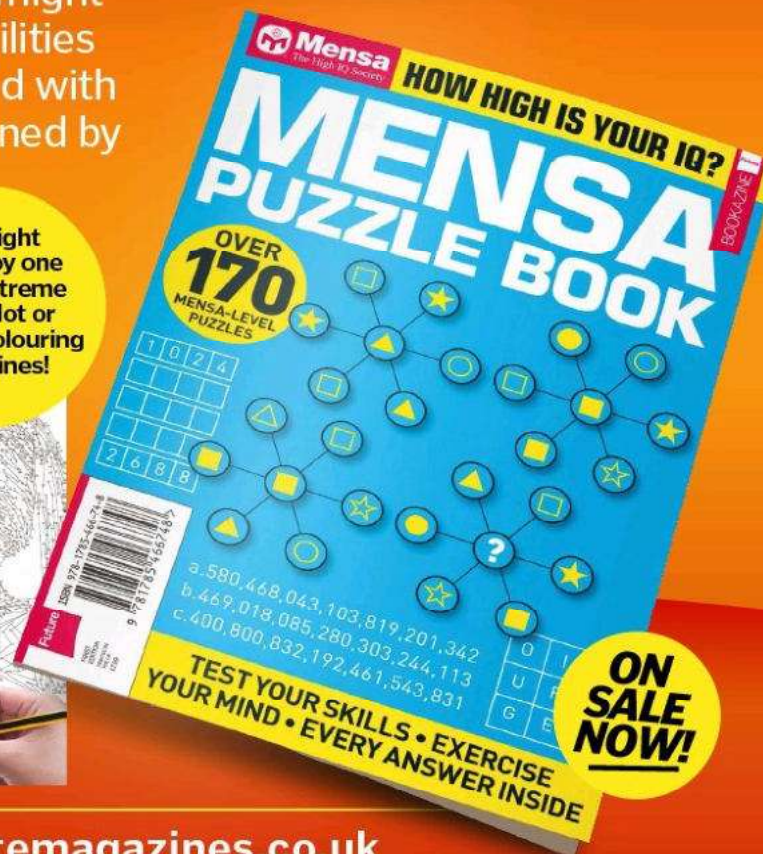
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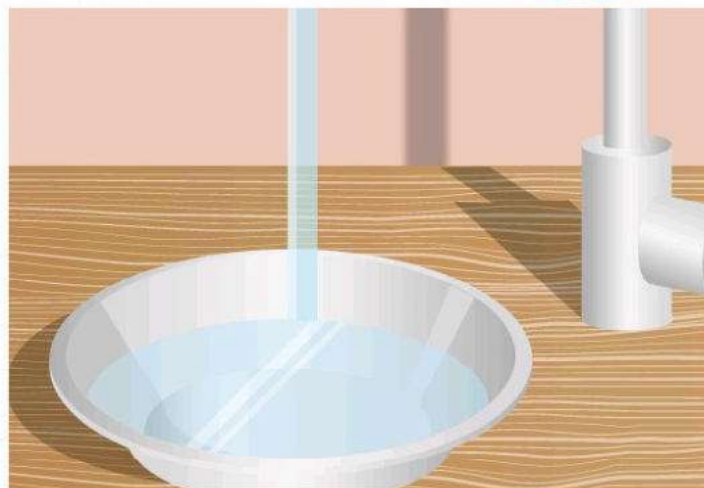
## Create an ice tower

Become a master of the elements as you transform water into a mountain of ice before your eyes!



### 1 Supercool your water

For this first step you'll need access to a freezer and a bottle of purified or filtered water. You'll have to ensure that the water is pure for this experiment, so use either sealed bottled water or tap water that's been run through a home filtering system and place it in a very clean bottle. Once you're confident that your water is squeaky clean, go ahead and place it in the freezer.



### 2 Prepare the platform

Now you need to leave the water to cool for around two and a half hours, but you can prepare the base of the tower while you wait. Find a small dish big enough to hold a small puddle of water. Ideally this should be made of metal — which gets nice and cold in the freezer — but any material that readily cools will do. Add some water straight from the tap and place the dish in the freezer.



### 3 Forge your tower

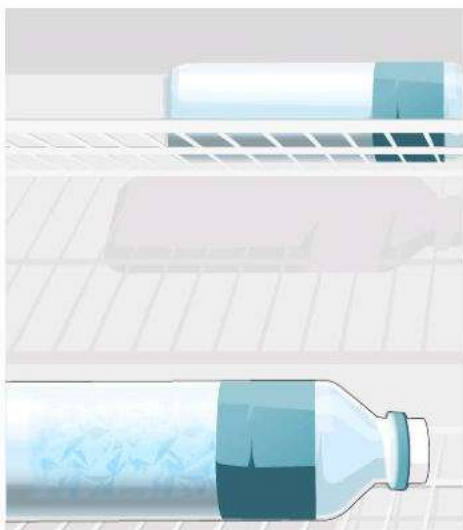
Once your bottled water has had time to supercool and the puddle in your dish has turned to ice, you're ready to create your tower. Take both the ice platform and the bottled water from the freezer and place the dish in a large bowl. Now pour your water over the block of ice and watch as it crystallises and transforms into a tower! Keep pouring to see the tower grow higher.



### 4 Experiment with crystals

Amazingly, an ice tower isn't the only way you can spontaneously form ice with supercooled water. For this next step you're going to need some more purified water (cooled in the freezer), an ice cube and a clean, clear glass. Pour your bottled water into the glass and drop the ice cube inside. The water will almost instantly begin to freeze and form lots of small crystals.





## 5 Test for impurities

Finally, try repeating the two experiments using less clean materials. To start, supercool one bottle of purified water next to a bottle of water taken straight from the tap. What do you notice happening when you try supercooling the dirty water? Now take the purified water and pour it into a dirty glass. What do you see? You may find that crystals are forming on their own.

*"Pour your water over the block of ice and watch as it transforms into a tower!"*

### In summary...

For water to form large shards of ice, the cooled molecules need solid pieces of debris to stick to. In purified water these tiny pieces are absent, but when we pour the water onto an ice cube, the cooled water can readily stick to the solid object and solidify, forming ice.

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**NEXT  
ISSUE**

BUILD A TEDDY  
BEAR ZIPWIRE  
MAKE A BATTERY  
USING COINS

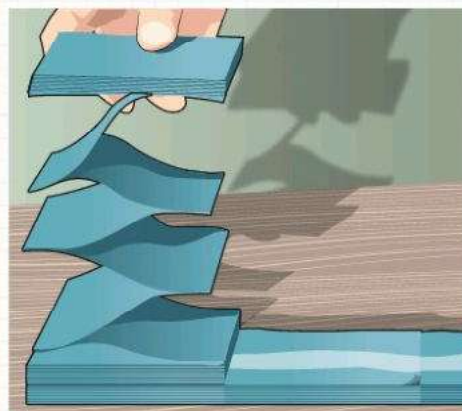
# Make a sticky note waterfall

Transform boring office stationary into a moving visual spectacle



## 1 Let's get started

To begin this experiment, first gather your required materials. You'll need at least nine blue zigzag sticky pads, a reel of tape, a couple of mugs and a platform between 0.5 and one metre in height, such as a box or a table. You can use glue to stick the notes together. For the first layer of your waterfall, arrange three sticky pads side by side, making sure all of the zigzags are running horizontally, and bind them with a strip of tape.



## 2 Bind the pads

Now that the first layer is completed, repeat the same pattern with three new pads on top of the base layer. Make sure you attach the sticky bottom of the pads to the base so that the layers are attached, or add glue to strengthen the bond. Add another strip of tape across the top three pads and repeat the process. When you've used all of your pads, carefully flip the whole collection over and add a strip of tape across the bottom.

## 3 Enjoy the show

You're now ready to run the waterfall. Move the pads to the top of your platform and place the two mugs so that they're hugging its sides. This will help keep the waterfall falling in a nice, straight line. Now quickly lift the top sheet of sticky pads up and over onto the ground, then watch as the other sheets stream after them! You can repeat this experiment with different coloured pads, creating a rainbow waterfall!

### In summary...

The sticky note waterfall works mostly through gravity, which is quite similar to a regular waterfall. After the top sheet is pulled to the ground, gravity tugs the other sheets down. As the sheets are stuck together they are pulled over the edge in a flowing sequence.

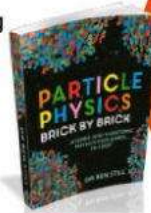
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## Letter of the Month

### Detecting gravitons

Dear HIW,

I have an idea about detecting a graviton. My idea is to have an environment where we think a graviton may appear equipped with particle detectors that can take pictures of the particles there. I am pretty sure that if a graviton does appear it would decay into smaller familiar particles, and if it does, I think it would decay into some low-energy particles. Now, I know that gravitons are extremely weak, so quantum computers should be used. How those quantum computers will work is that electrons will be fired into a box with an equal probability of landing anywhere. Each place that an electron could land on will represent a symbol. Different combinations of symbols will mean different things. Because there are a lot of places an electron could land on, just two electrons could have lots of possible combinations. But, if we use electrons with a superposition of spin up and spin down for the quantum computers, then the possible combinations of them would be just four. The quantum computers I'm planning to use to detect a graviton will be very powerful, so we might be able to detect a graviton.

Andrei Banciu, aged 10

Thank you very much for such a brilliant letter. Now, as you are aware, gravitons, if they exist, are extremely difficult to detect, and our best chance of finding them is



Gravitons are thought to be the carriers of gravitational fields

using an incredibly powerful experiment, such as the Large Hadron Collider (LHC). It's thought that the graviton could decay in a few possible ways: either into two photons or two jets, or bursts of hadrons. Knowing where gravitons appear in order to put your idea to work is very tricky. However, given our detection of gravitational waves (which could be made up of these particles), researchers are thinking that the universe could actually serve as one big detector; bigger than the LHC and much more powerful than the quantum computer you suggested.

It's thought that we could detect gravitons by looking for small changes, or fluctuations, in the cosmic background radiation, which is the radiation left over from the

birth of the universe. It's suspected that after the Big Bang the cosmos quickly underwent an 'inflation' phase, and it's here that, if gravitons exist, they would be generated as 'quantum fluctuations' during this rapid and dramatic growth.

Clearly, this is a new area of research, and it could be that there's no chance of detecting the graviton this way. When hunting for the graviton, particle physicists use beams of protons - rather than the negatively charged electron - in the hopes of creating the region of empty space where the momentum and energy are out of balance and which could give away the presence of this elusive, massless particle.

Answered by Dr Gemma Lavender, Editor of *All About Space*

### Boiling veg with bicarb

Hello HIW,

In your article on chemistry life hacks in October's issue you mention keeping veggies green and you also have three bicarbonate of soda hacks. But the best way to keep veggies green, even if you boil them to death in true British style, is to add a bit of bicarb to the water. This keeps the pH up and stops the magnesium being

displaced by hydrogen in the chlorophyll. Hey presto! Bright green cabbage. Alice Bexon

That's a great tip Alice! Bicarbonate of soda seems to have more uses than we realised. From baking bread to cleaning cutlery, the humble bicarb is a life hack essential!



Bicarbonate of soda comes from the mining of trona mineral ore

### Minty fresh

Dear HIW,

I have been a subscriber to *How It Works* for over two years and I have loved every issue. I was wondering, why does my mint shower gel make me cold? Thanks, Henry Jalland, aged 16

Thanks for the question Henry! Mint contains menthol, which can really mess around with how you perceive

temperature. Your nerves are telling your brain it is cold, when it's not really because it triggers a protein called TRPM8 in your skin. This causes the cold receptors to become particularly sensitive and over fire. Nobody is sure why this happens, but it's likely that the menthol 'key' just fits perfectly with the cellular 'lock'. Thanks for the question Henry.

What's happening on...

## social media?



This month, we asked you what science conspiracy theories you had heard

*Time-travelling Daniel Radcliffe is a personal favourite*

@JoStass

*I heard one that said that aliens built Stonehenge*

@William14765156

*Maybe not a big deal with your UK readers but there's a theory that Michael Jordan's surprise departure from basketball (where he was a megastar) to play baseball (where he was a dud) was that he was actually serving a 2-year suspension for gambling.*

@Ginsburg

And our favourite Twitter exchange of the month...

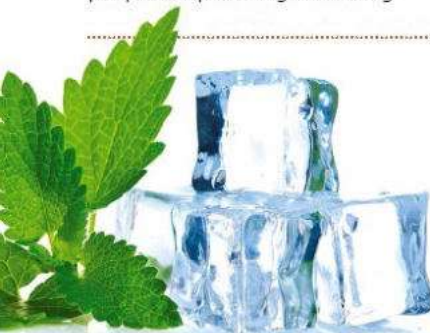
*Why is there no Flat Mars Society!?*

@elonmusk

*Hi Elon, thanks for the question. Unlike the Earth, Mars has been observed to be round.*

*We hope you have a fantastic day!*

@FlatEarthOrg





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ONE STUDY FOUND THAT UP TO  
**30%** OF AMERICANS BELIEVE IN  
THE 'CHEMTRAILS' CONSPIRACY

**5,802KM<sup>2</sup>**

THE AREA OF THE ICEBERG THAT BROKE OFF  
THE LARSEN C SHELF IN JULY 2017

THE SONG OF A MALE  
HUMPBACK WHALE CAN BE  
HEARD FROM A DISTANCE OF

**30KM**

**130M**

THE LONGEST  
UNSUPPORTED  
TIGHTROPE WALK

OVER  
**17,400**

NEAR-EARTH ASTEROIDS  
ARE KNOWN

SINCE 1562,  
VENETIAN  
GONDOLAS HAVE  
HAD TO BE PAINTED  
BLACK BY LAW

**4,175,885KG**

THE AMOUNT OF GOLD HELD IN FORT KNOX

THE MINERAL-RICH  
WATERS OF THE BATH  
HOT SPRINGS ARE

**46°C**

WHEN THEY REACH  
THE SURFACE

THE ORIGINAL  
FORD MUSTANG SOLD OVER

**1 MILLION**

UNITS IN 18 MONTHS AFTER ITS LAUNCH IN 1964

THE LARGEST SINGLE CELL ON EARTH WAS THE  
EGG OF THE NOW-EXTINCT ELEPHANT BIRD

MARS 2020 WILL BE  
THE FIRST MARTIAN  
ROVER TO HAVE 2  
MICROPHONES

AT LEAST

**17**

DISEASES ARE DETECTABLE  
FROM A PATIENT'S BREATH

**12,000**

THE AMOUNT OF SPECIES  
OF MOSS IN THE WORLD





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